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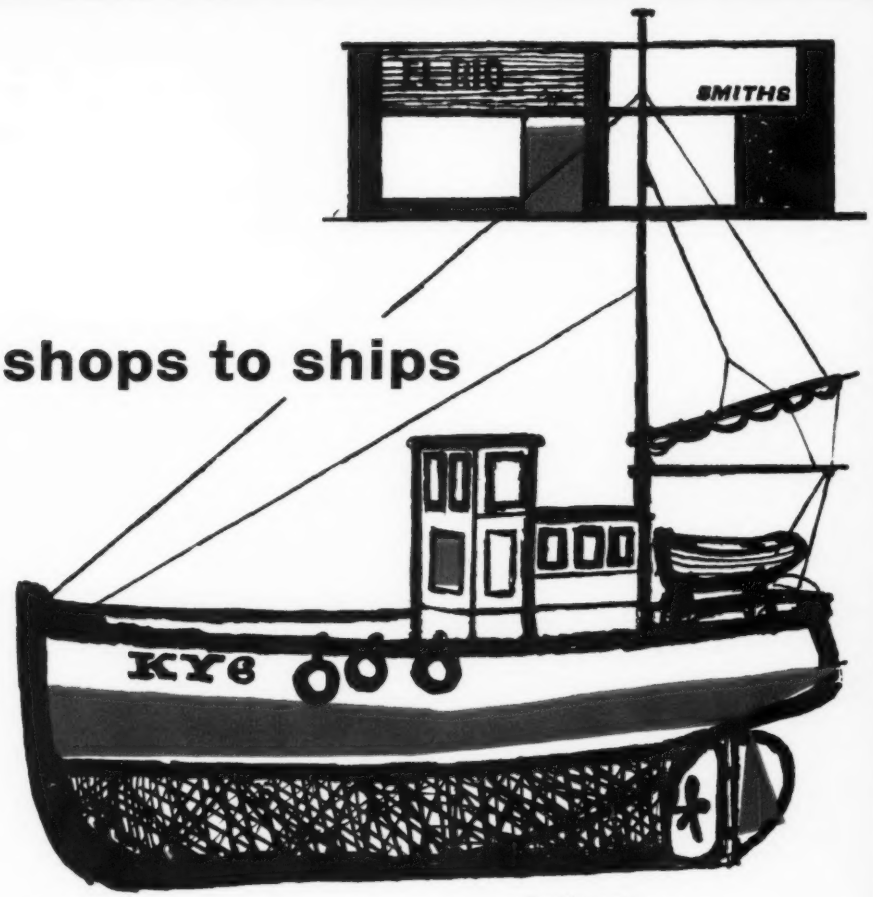
METAL INDUSTRY

THE JOURNAL OF NON-FERROUS METALS



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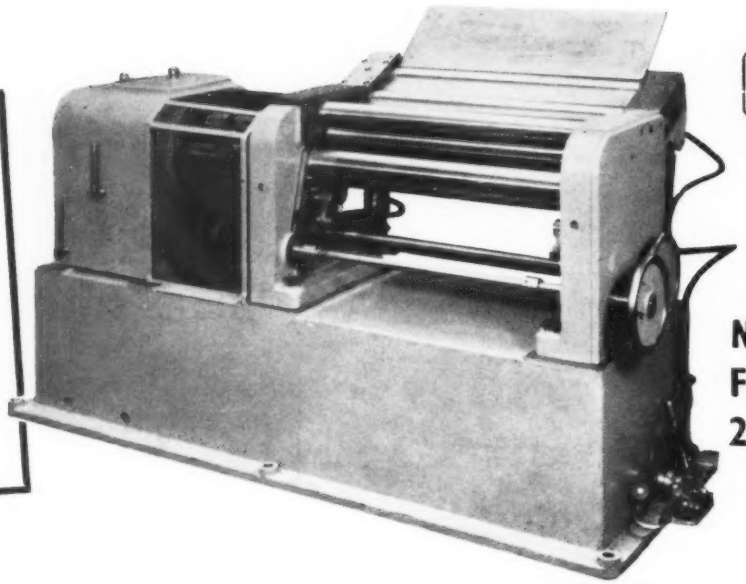

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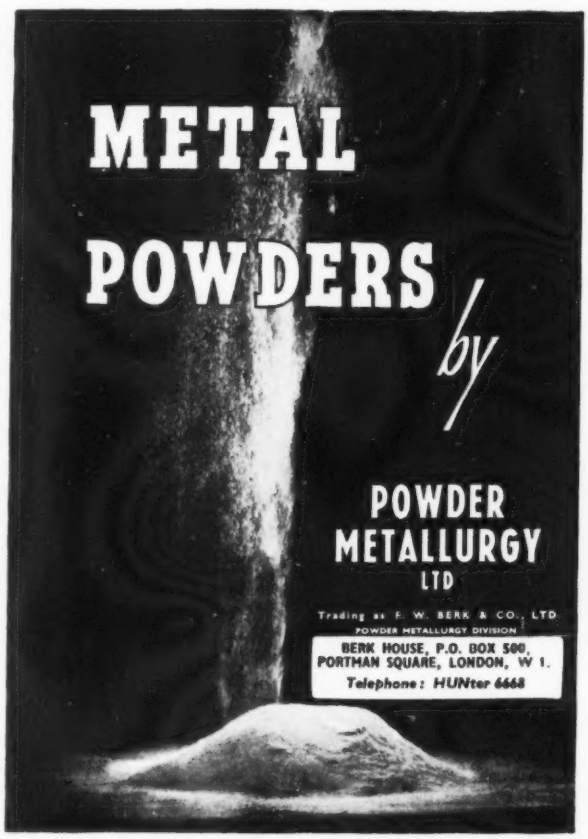

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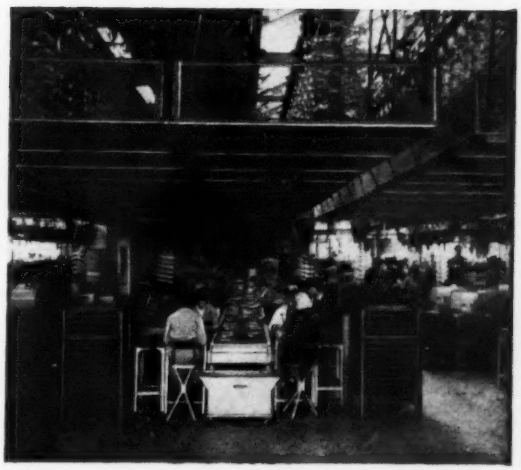

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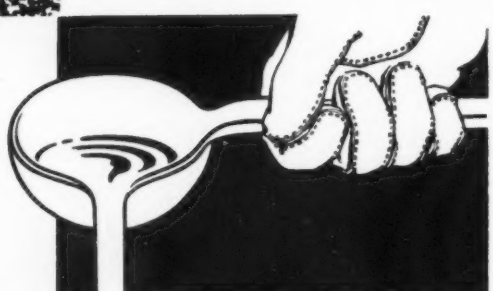

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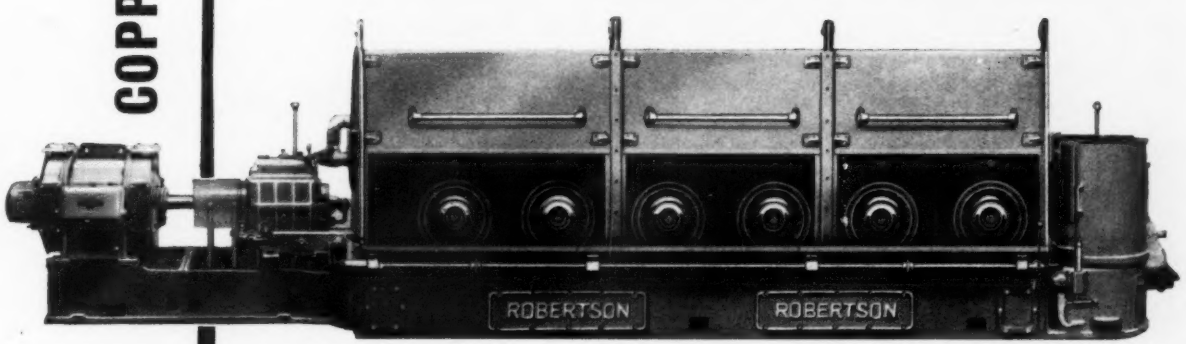

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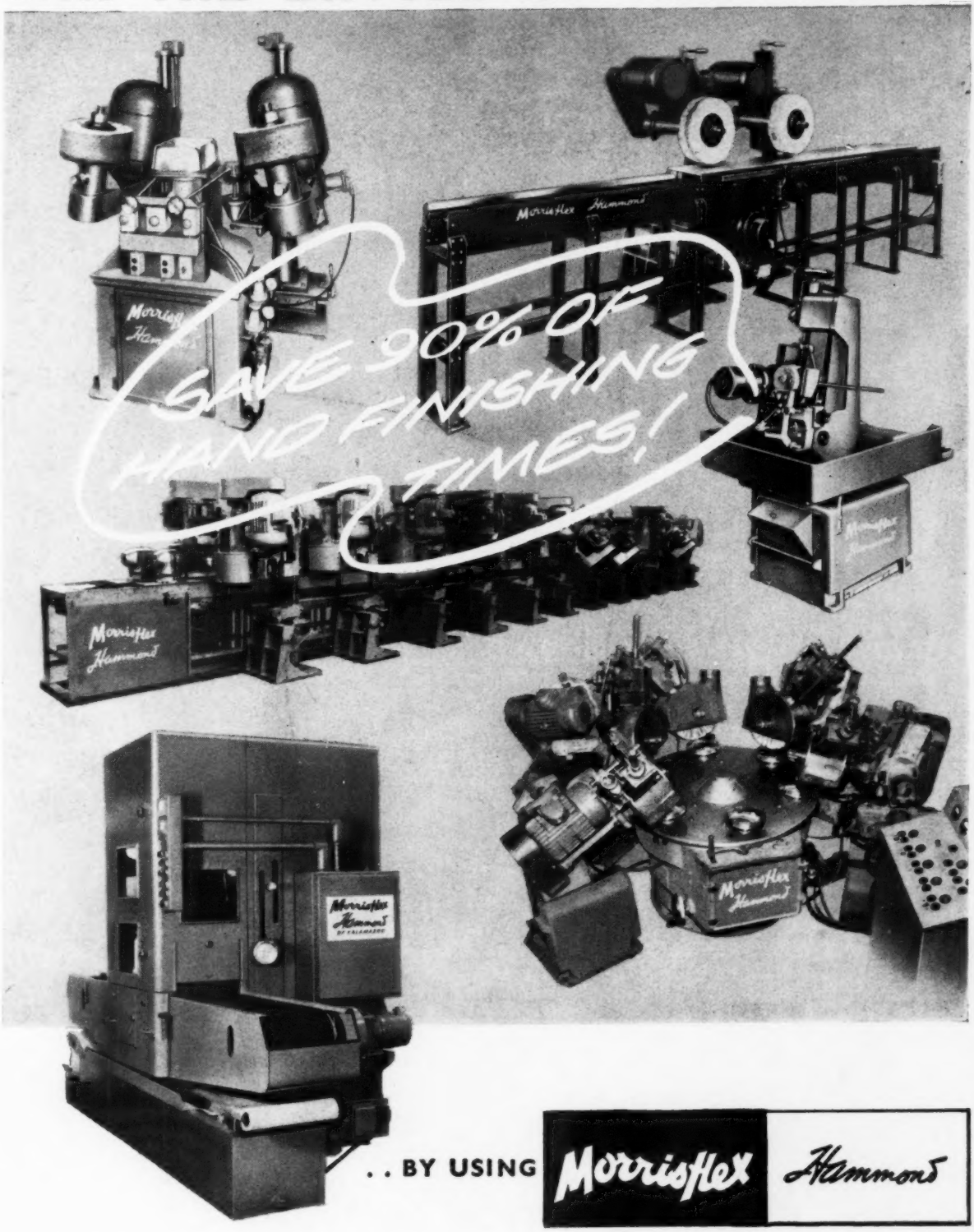

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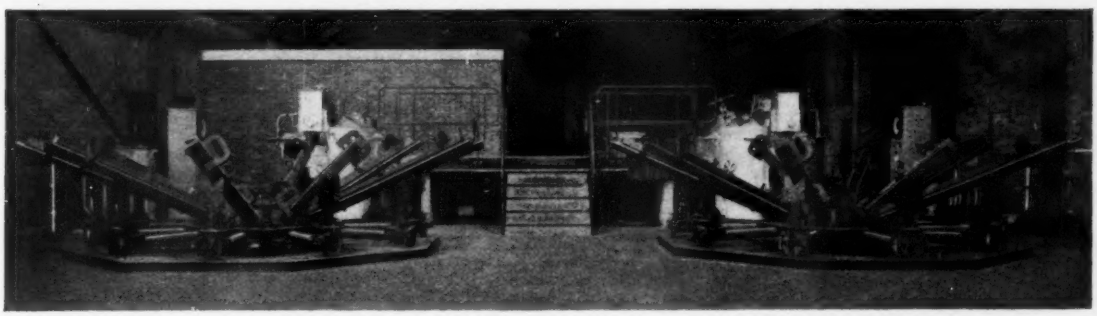

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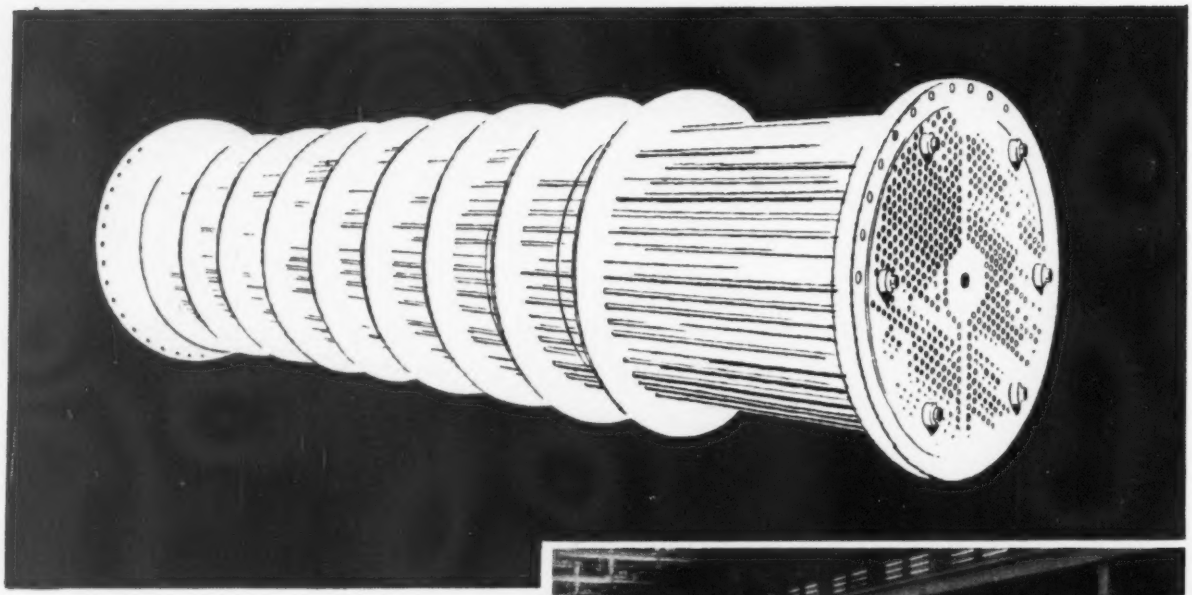

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METAL INDUSTRY

FOUNDED 1909

EDITOR: L. G. BERESFORD, B.Sc., F.I.M.

13 MARCH 1959 VOLUME 94 NUMBER 11

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METAL INDUSTRY

VOLUME 94 NUMBER 11 13 MARCH 1959

Prognostication

WAY back in 1952 the Paley Report was rash enough to make predictions of metal production and consumption up to the year 1975. Some aspects of this Report were re-appraised at the recent annual convention of the A.I.M.E., and it was reported that out of the seventeen items for which the report made projections of demand, the actual 1957 United States domestic consumption of nine of them was within 10 per cent of the Commission's figure on a straight line projection from 1950 to 1975. If a 20 per cent margin of error can be taken as reasonable the predictions are good for four or five more metals, including lead and zinc. Only two items were completely out of line, namely cobalt, where consumption in 1957 was 50 per cent lower than the Paley estimate, and aluminium, whose consumption was 100 per cent higher than that predicted. Thus, by 1956 the consumption of light metals had increased more than 20 per cent beyond the Commission's expectations, a growth not anticipated by the study until 1960. An annual increase of 7 per cent in consumption had been anticipated, whereas actually before the recession aluminium usage had risen 10 per cent annually to a peak usage of 2,000,000 tons in 1956, double the consumption of 1950. It is of interest to note that whereas the report anticipates an annual consumption of 4,500,000 tons of aluminium by 1975, informed opinion in the industry predicts that it will be closer to 10,000,000 tons by that date. In considering these discrepancies it should be remembered that the Commission placed less confidence in its aluminium figures than in the others.

Predictions for free world consumption are not so good as those for the U.S. alone, but are still creditable. Generally speaking, the Commission tended to underestimate the growth of world demand. Even so, about half of the predictions at the 1957 year point are within 20 per cent of the actual figures, including copper, lead, zinc, and aluminium. Domestic consumption for copper is higher than the report anticipated, and the expected decline in lead production to 350,000 tons has already been realized. Some increase in zinc production was forecast and, in point of fact, an upward trend existed during the first three years. Low prices from world overproduction and recession conditions, however, have since brought domestic production well below that of 1950. Again, the report predicted that copper, lead and zinc would continue scarce, but, as is only too well known, instead of scarcity there has in the past year been over-abundance. Nevertheless, it would not be quite fair to base judgment on an abundance due to an abnormal recession. If domestic consumption had continued on a normal upward trend it is probable that metal supplies would have been merely adequate instead of over-abundant.

It will also be remembered that the report drew certain conclusions as to costs, saying that "the pressure against limited resources is boosting real costs" for some items at least. For example, the Commission anticipated that the ultimate rise in the prices of lead and bismuth might be relatively severe, and increases were expected also for chromium, nickel and tungsten, but not necessarily for copper and zinc. Appraisal of the value of these forecasts during the last seven years is extremely difficult, particularly as professional economists themselves differ in opinion as to how to measure costs in the present sense and, therefore, any available indices are inconclusive if not conflicting. Nevertheless, it can be said that the value of metals and minerals (except fuel) produced in the U.S. has been rising faster than has been the Gross National Product. As compared with a 1947-49 average, and corrected for inflation, the increase by the end of 1956 was 40 per cent for the non-ferrous metal group, perhaps about 55 per cent for all metals, and 55 per cent also for iron ore. It will be interesting to see how the prophecies of the Paley Report fare in the next quinquennium.

Out of the MELTING POT

Hints

ONE difference between technical and general news is that the former cannot be announced in too few words without the announcement becoming a liability rather than an asset. News such as "dog bites man," or vice versa, can be published in as little as a headline or two without much loss. Very often the paragraph giving the details adds little of value. The temptation to act as if the same applies to news in the technical and scientific fields is considerable. The excuse is, of course, that these short announcements save the reader's time, that they bring to his notice developments which he might otherwise have overlooked through lack of time to read a long article in which they might have been dealt with in greater detail and, it is also claimed, such announcements provide a means of bringing news of developments before the readers more quickly than if it were necessary to wait for time and space for the publication of a detailed account. Given these excuses, one is presented with increasing numbers of news items ranging in length from paragraphs to headlines. Quite a number of them succeed in arousing one's interest, but there is no denying the trouble it is, once interest has been aroused, to get hold of additional information. Finally, and unfortunately, there is also no denying that sometimes it proves impossible to do this, that sometimes the announcement refers to a secret process or one for which patent applications are being made and about which no further information can be made available, that the announcement is based, unrecognizably, on a detailed article or Paper one has read some time ago, or that some garbling of the subject matter has occurred in the process of condensing it. What, I wonder, is the full story behind the announcement that "extrusion of metal by ultrasonic energy is in early developmental stage, W. C. Pothoff, vice-president Aeroprojects, Inc., West Chester, P., has revealed. Rate of extrusion can be increased, or force for given extrusion rate can be reduced"? My interest in the matter is heightened by the query (with no story behind it) as to what could be the effect of using ultrasonics to vibrate extrusion and drawing dies (this page, METAL INDUSTRY, 23 January 1959, p. 62).

Pointers

ONE obvious advantage of spotting a trend in its very early stages is the opportunity it provides of falling into line, or even of getting ahead. Later, whereas falling into line is much easier, spotting any future developments that still remain to be spotted is much more difficult, and the rewards therefrom are much smaller. That is why the familiar inclination of doubting evidence of an incipient trend should always be firmly suppressed. Bearing the above preamble in mind, it should be easier to devote a thought or two to the faintly perceptible trend towards metal fabrication processes involving an atomizing step in the broadest meaning of the term atomizing. Indeed, the trend may be as yet non-existent, but there are at any rate a number of factors, and some widespread but as yet hardly articulate interest, all of which are likely to come together in the not too distant future and get such a trend going. The ultimate aim of such a trend would be a process in which an electronically controlled beam of ions of the required metals would be used to build up a finished part having the exact shape, size, composition and properties required. Like all ultimate aims, this may sound like science fiction, but then even science fiction is being taken seriously these days. Consequently it behoves one to take even more seriously the possibility of realizing the above trend by making use of finer and finer metal powders, and considering ways and means of putting particles of them together that would be more refined than the present variants of squeezing them in bulk. Fluidization techniques might help in this connection. So far as the casting field is concerned, the trend would be towards handling molten metal in the form of smaller and smaller droplets rather than in the large volumes in which it is handled at present. Vacuum induction, arc, plasma, and electron bombardment melting techniques would help in this connection. Finally, promising opportunities for rapid progress of the trend are likely to be found in the metal vapour vacuum coating field. Is all the current work on developing improved methods and means for evaporating metals in vacuum to lead solely to the deposition of metals in the form of films? Would it not be possible for vacuum coating to develop the equivalent of the electroforming process? In doing this it would certainly be falling into line with the (did I say as yet non-existent?) trend.

Another One

ANY readers who were interested in the recent paragraph (this page, METAL INDUSTRY, 27 February 1959, p. 162) describing an instance of precipitation (in the chemical sense of the term) in the metallurgical field may like to note another example of an intermetallic reaction leading to the formation of a precipitate, again in the chemical sense of the term. The analogy with precipitation in the chemical sense is, in fact, even closer because, while the precipitate formed by reaction between two constituents when the melts in which they are dissolved are mixed is allowed to remain where it is formed, the precipitate formed in this second example is actually recovered for subsequent independent use. This particular precipitation is carried out using mercury as a solvent. It has been discovered that by reacting nickel amalgam with aluminium or aluminium amalgam, an extremely fine powder of mercury-free nickel aluminide (NiAl) is formed. The reaction is preferably carried out at a temperature between 450° and 750°C. The NiAl powder is separated from the mercury by decantation or filtration. The fine-grained powder obtained in this way has proved to be well suited for use in the manufacture of various heat-resisting compositions by powder metallurgy. In this connection it has proved superior to NiAl materials available hitherto, which have suffered from brittleness. In making parts from the NiAl powder precipitate, aluminium powder may be added together with nickel amalgam to act as a binder. During subsequent sintering the mercury evaporates and the remaining nickel reacts with the aluminium to form $NiAl_3$, a material consisting of $NiAl_3$ with some NiAl being obtained. Alternative binders include hydrolyzable silicic acid compounds, e.g. silicic acid esters, or colloidal alumina, and additions of silicon, disilicides and alumina may be made.

Skimmer

PROCESSES AND METHODS FOR WORKING HIGH TEMPERATURE MATERIALS

Fabricating High-Strength Superalloys

By H. E. HALEY

With the widespread demand for alloys having exceptional high temperature properties, attention has been more and more directed towards the ferrous materials with high alloying additions of nickel, tungsten, molybdenum and chromium, and towards cobalt- and nickel-base alloys. This article, which is a slightly condensed version of a Paper given before the American Society of Tool Engineers, discusses some of the problems affecting the fabrication of these alloys and the methods that have been developed to overcome them.

SUPERALLOYS are generally regarded as those materials which are required to operate at temperatures from 650°C. to temperatures within 40°C. of their melting points.

The major alloys available for high-temperature service prior to World War II[1] may be regarded as falling broadly into two groups. These were the martensitic, ferritic, and austenitic stainless steels, as exemplified by A.I.S.I. numbers 410, 430 and 310 respectively, and the nickel-chromium-iron alloys characterized by the casting grades of heat-resisting alloys similar to A.I.S.I. number 330, commonly known as "35-15."

As always, necessity has been the mother of invention and World War II hastened the advent of the true superalloy. In Table I an attempt has been made to classify superalloy development in terms of the major alloying elements. This table also roughly plots these groups of alloys in their order of increasing strength at elevated temperatures.

Several of the nickel-base alloys were available prior to World War II, but they were used almost exclusively for corrosion resistance, and their excellent elevated-temperature properties were not exploited until a nickel-molybdenum alloy was used for blading in an early General Electric gas turbine.

Table II lists the composition of a typical alloy in each of these groups, while Table III shows the approximate rupture strength of these same materials at 650°C., 820°C. and 980°C.

Welding

Although these superalloys have been described in terms of their heat-resistance, all have some degree of corrosion resistance. In fact, some of these alloys were originally developed for resisting various corrosive media, but have found increasing use in high-temperature applications. The converse is also true. The nickel-molybdenum-chromium and nickel-molybdenum-chromium-iron alloys are good examples of materials designed for corrosion resistance but used extensively in elevated temperature applications. The requirements of superalloys for corrosion-resistant service are also increasing, because of increases in operating temperatures in the chemical process industry.

High alloys may be separated into three groups according to the types of exposure in service to which they are usually subjected: (1) corrosion; (2) heat (good oxidation resistance and load-carrying ability necessary); (3) combined corrosion and heat.

The joining processes that are generally used for stainless steel are

TABLE I—CLASSIFICATION OF SUPERALLOYS

Useful Temperature (approx. °C.)	Alloy Type
To 705	Iron Base
To 750	Ni-Mo
To 820	Ni-Mo-Cr and Fe-Cr-Ni-Co
To 870	Ni-Cr-Fe-Mo
To 980	Ni-Cr-Fe-Mo (Al-Ti)
To 1100	Co-Cr-W-Ni

TABLE II—CHEMICAL COMPOSITION OF TYPICAL SUPERALLOYS

Alloy	Ni	Co	Cr	W	Mo	Fe	C	Si	Mn	Al	Ti	Cb+Ta
Iron-Chromium-Nickel-Cobalt	19·0—21·0	18·5—21·0	20·0—22·5	2·0—3·0	2·5—3·5	Bal.	0·08—0·16	1·0 Max.	1·0—2·0	—	—	0·75—1·25
Nickel-Chromium-Iron-Molybdenum	Bal.	0·5—2·5	20·5—23·0	0·2—1·0	8·0—10·0	17·0—20·0	0·05—0·15	1·0 Max.	1·0 Max.	—	—	—
Nickel-Molybdenum	Bal.	2·5 Max.	1·0 Max.	—	26·0—30·0	4·0—7·0	0·05 Max.	1·0 Max.	1·0 Max.	—	—	—
Nickel-Molybdenum-Chromium	Bal.	2·5 Max.	14·5—16·5	3·0—4·5	15·0—17·0	4·0—7·0	0·08 Max.	1·0 Max.	1·0 Max.	—	—	—
Nickel-Chromium-Iron-Molybdenum (Al-Ti)	Bal.	2·5 Max.	14·0—17·0	—	4·5—6·5	9·0—11·0	0·16 Max.	1·0 Max.	1·0 Max.	1·75—2·25	2·25—2·75	—
Cobalt-Chromium-Tungsten-Nickel	9·0—11·0	Bal.	19·0—21·0	14·0—16·0	—	3·0 Max.	0·05—0·15	1·0 Max.	1·0—2·00	—	—	—

TABLE III—RUPTURE STRENGTH OF TYPICAL SUPERALLOYS

Alloy	Typical Rupture Strength (1000 lb/in²)					
	650°C.		820°C.		980°C.	
	100 hr.	1000 hr.	100 hr.	1000 hr.	100 hr.	1000 hr.
Fe-Cr-Ni-Co	60*	49*	20†	16†	—	—
Ni-Cr-Fe-Mo	44	33	14·5	—	5·2	3·0
Ni-Mo	50‡	36·5‡	16·2‡	10·0‡	—	—
Ni-Mo-Cr	55	43	18·0	12·5	—	—
Ni-Cr-Fe-Mo (Al-Ti)	84	63	38	28	6·9	4·6
Co-Cr-W-Ni	—	—	22	17	7·5	5·0

* *As forged.* † *Aged 4 hr., 820°C.* ‡ *Aged 72 hr., 820°C. Solution Heat Treated Bar.*

TABLE IV—WELDING GUIDE FOR SUPERALLOYS

	Metallic Arc	Shielded Arc	Submerged Arc
Fe-Cr-Ni-Co Ni-Cr-Fe-Mo Ni-Mo Ni-Mo-Cr Ni-Cr-Fe-Mo (Al-Ti) Co-Cr-W-Ni	Direct Current Reverse Polarity Electrode Positive	Direct Current Straight Polarity Electrode Negative	Direct Current Reverse Polarity Electrode Positive

applicable to the high alloys, with or without some variations. The processes to be discussed are those used currently in the fusion welding of nickel- and cobalt-base, corrosion- and heat-resistant alloys. The data accumulated in the evaluation of the processes, techniques and procedures are (except where noted) based on the use of wrought, mill-annealed base material.

Since all of the processes discussed may produce satisfactory joints, the choice of the process is determined by: alloy grade; metal gauge; weldment design; joint design; joint position; special problems incurred in erection or fabrication.

Good properties are exhibited in as-welded joints. For maximum corrosion resistance, however, the material should be given a solution-type heat-treatment after welding.

In all instances, the welding surface and adjacent base metal should be thoroughly cleaned down to bright metal immediately before welding. All grease, oil, crayon marks, dirt, etc., should be removed. If foreign materials are present in the forms mentioned, they may be removed by scrubbing with trichloroethylene or some other suitable solvent material. The surface should be wiped clean before welding.

Many types of joints are used in the fabrication of fusion-welded equipment. The type chosen will not necessarily change with a change of welding process since these joint designs are standard. To make these joints suitable for automatic welding operations, such as submerged arc or inert-gas-shielded arc, certain slight modifications may be necessary.

These alloys do not have the fluidity of steel during a welding operation. Therefore, when "V" or "U" or "J" grooves are used, it is necessary to provide a slightly larger clearance than would be needed for steel. This larger clearance allows for cleaning and better accessibility during welding. In general, V joints should be bevelled to a 75°-80° included angle, U joints bevelled to a 30° included angle with a minimum of a $\frac{1}{4}$ in. bottom radius, and J grooves should have a 15° bevel with a minimum bottom radius of $\frac{3}{8}$ in. Tee joints between dissimilar material thicknesses should have a bevel of 45°. Some of these joint types are shown in Fig. 1.

The use of backing rings should be avoided when designing containers or pipe lines to be used for carrying corrosive media. Crevices cannot be avoided in this type of design, and these may become points of cell-type and stress corrosion, notch effect and root cracking.

In general, material 11-gauge and heavier should be bevelled and welded from both sides. When joining material of dissimilar thickness, the heavier section should always be bevelled for ease of welding. For material 12-gauge and thinner, the welding may be accomplished from one side by using proper edge spacing to allow full penetration. Care should be exercised to eliminate non-uniform penetration. This condition can leave undesirable crevices and voids in the underside of the joint which, as noted before, contribute to areas of accelerated corrosion. Non-uniform penetration in material used for high-temperature applications creates stress risers for focal points of mechanical failure.

Welding from both sides is recommended wherever possible. When this is not practicable, the joint spacing should be increased and a copper backing bar used. Currents slightly higher than normal are then used to obtain complete penetration.

Bevelling by machine is the surest way to obtain correct fits. A planer, shaper, grinder or other machine tool can do this job accurately. When sheared sheet or plate is used, the sheared edges should be ground back approximately $\frac{1}{16}$ in. to remove any stressed material before the edge is prepared for welding. In all instances, the edges should be squared, aligned properly and tacked before welding. The alignment and edge preparation are particularly important in this class of alloys. Any misalignment causes variation in bead contour, gap width, and stresses in the weld area. These factors contribute to cracking in the weld joint. Since the initial metal cost is fairly high, the slight additional cost of careful preparation to assure good welds is well justified. Thermal cutting and bevelling of plates can be done, but these are not recommended procedures.

In general, the "V" joint preparation is used for butt welds in plate thicknesses up to $\frac{1}{4}$ in., and a "U" joint for greater thicknesses. The "V" or "U" joint is used where the welded material will be exposed to high stress. When these types of weld construction are used, the stress will act axially. The lap or tee joint may be used for conditions of lower stress.

The "U" joint preparation is preferred for material greater than $\frac{1}{4}$ in. in thickness. While the cost of preparation may be increased by this type of joint, the amount of welding materials and man-hours needed for welding will be much less than if a "V" joint is used. Also, the amount of residual stress will be lower, since less weld material is required and less transverse shrinkage is incurred.

Jigs and Fixtures

The use of jigs and fixtures for assembly and subsequent welding provides definite economies in reduced welding cost, greater speed in welding, and ease of producing welds of uniformly high quality. Proper jigging and clamping of the weld joint makes the welding operation easier, and holds buckling and warping to a minimum. It is generally desirable to provide a grooved backing bar of some sort. This serves as a chill to the base material and as a support to excessive hang-through of the weld bead. The use of a backing bar contributes to the ease of welding and helps to obtain a more uniform bead penetration.

Steel or cast iron may be used in fixtures for oxy-acetylene welding. When the arc process is used, the portion of the fixture contacted by the arc should be copper.

When using a backing or chill bar, a groove of the proper contour is usually provided to permit good penetration and bead contour. For oxy-acetylene welding, the backing bar should be grooved to $\frac{1}{16}$ in. deep and about $\frac{5}{16}$ in. wide. The groove width and hold-down spacing should be adjusted to obtain the best conditions of heat transfer, plate hold-down and ease of welding. For arc welding, the grooves should be of a minimum depth, usually from $\frac{3}{32}$ in. to $\frac{1}{16}$ in., and approximately $\frac{3}{16}$ in. wide. The corners of the groove should be rounded. Square corners cause poor bead contour, flux pockets, and non-uniform heat transfer. Jigs and fixtures can be used to particular advantage when using the inert-gas-shielded arc process.

The superalloys considered here can be welded by any of the conventional methods; however, oxy-acetylene is not recommended for corrosion-resistant fabrications due to the danger of carbon pick-up. Table IV shows the preferred current supply and polarity

TABLE V—WELDING Ni-Cr-Fe-Mo ALLOY

Submerged-Melt Welding

Base Metal Thickness (in.)	Rod Diameter (in.)	Current (amp.)	Travel Speed in/min.
$\frac{1}{8}$	$\frac{1}{8}$	275	18
$\frac{3}{8}$	$\frac{1}{8}$	300	16

Sigma Welding

Base Metal Thickness (in.)	Rod Dia. (in.)	Current (amp.)	Argon Flow ft³/hr.	Travel Speed in/min.
$\frac{1}{8}$	$\frac{1}{16}$	275	30	20
$\frac{1}{4}$	$\frac{1}{16}$	300	35	16
$\frac{3}{8}$	$\frac{1}{16}$	300	35	16

Metallic-Arc Welding

Rod Diameter (in.)	Amperage	Voltage
$\frac{1}{16}$	40-60	18-22
$\frac{5}{64}$	50-70	20-24
$\frac{3}{32}$	60-90	22-26
$\frac{1}{8}$	80-120	22-26
$\frac{5}{32}$	90-130	22-26
$\frac{3}{16}$	110-170	22-26

Inert-Gas-Shielded Arc Welding

Base Metal Thickness (in.)	Rod Diameter (in.)	Current* (amp.)	Argon Flow ft³/hr.
$\frac{1}{16}$	$\frac{1}{16}$	50	30
$\frac{3}{32}$	$\frac{3}{32}$	75	30
$\frac{1}{8}$	$\frac{1}{8}$	90	35
$\frac{5}{32}$	$\frac{1}{8}$	105	35
$\frac{1}{4}$	$\frac{1}{8}$	105	35
$\frac{3}{8}$	$\frac{1}{8}$	105	35

* *Direct current, straight polarity*

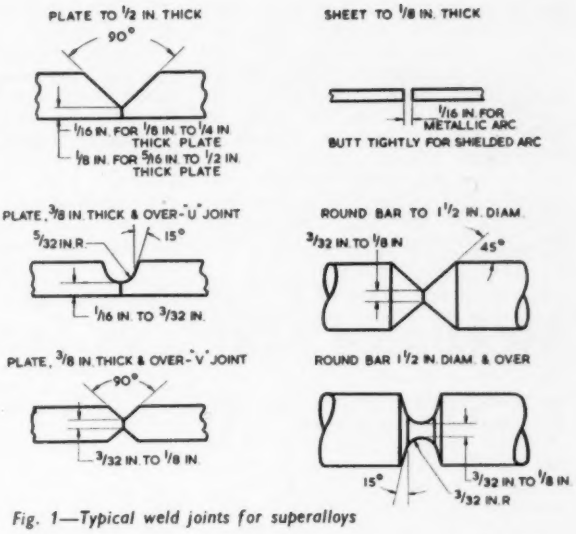


PLATE TO 1/2 IN. THICK
90°
1/16 IN. FOR 1/8 IN. TO 1/4 IN. THICK PLATE
1/8 IN. FOR 5/16 IN. TO 1/2 IN. THICK PLATE
SHEET TO 1/8 IN. THICK
1/16 IN. FOR METALLIC ARC
BUTT TIGHTLY FOR SHIELDED ARC
PLATE, 3/8 IN. THICK & OVER-"U" JOINT
5/32 IN. R
15°
1/16 IN. TO 3/32 IN.
ROUND BAR TO 1 1/2 IN. DIAM.
3/32 IN. TO 1/8 IN
45°
PLATE, 3/8 IN. THICK & OVER-"V" JOINT
90°
3/32 IN. TO 1/8 IN.
ROUND BAR 1 1/2 IN. DIAM. & OVER
15°
3/32 IN. TO 1/8 IN.
3/32 IN. R

Fig. 1—Typical weld joints for superalloys

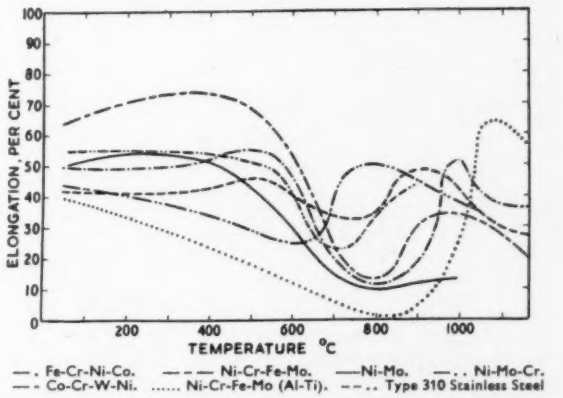


Fig. 2—Elongation of typical superalloys compared with type 310 stainless steel

for these alloys in metallic-arc, inert-gas-shielded arc and submerged-arc welding. It should be emphasized that submerged-arc welding generally results in low ductility welds having bend factors of only 15°-20°. Submerged-arc is not recommended for welding heavy plate in the iron-chromium-nickel-cobalt alloy because of a microfissuring tendency.

A detailed description of the recommended amperages and voltages in all methods for the nickel-molybdenum-chromium-iron alloy is given in Table V.

In inert-gas-shielded arc welding, electrodes are normally operated at maximum current density in order to obtain the best arc stability. It has been found, however, that the use of $\frac{1}{16}$ in. diameter electrodes under these conditions in some cases creates excessive electrode contamination and results in excessive tungsten deposits in the weld puddle. This problem is materially reduced by using a $\frac{3}{32}$ in. diameter electrode ground to a needle-like point. The nickel-molybdenum alloy is prone to develop porosity from excess nitrogen, and care must be taken to prevent aspiration of air into the weld deposit; proper joint design and shielding the reverse side of the weld minimize this condition. Inert-gas-shielded arc welding has been generally accepted as the best method of joining materials to be used in corrosion applications. Welds produced by this method are of slightly higher quality than those obtained with the metallic-arc method. Possible slag inclusions, pick-up of stray elements from the coating, excessive burn-out of metallic elements in the rod, etc., are not as pronounced.

A study of the mechanical properties of the alloy before designing the weldment will be helpful, too (see Fig. 2). Notice the drop in ductility in the "hot-short" range of these alloys between the approximate temperatures of 480°C. and 980°C. These data represent the characteristics of the alloys and are directly related to the way they perform during welding and subsequent cooling cycles. From these data it can be seen that it is important to pass through the temperature range of 600°-980°C. as rapidly as possible during cooling, and to design and position the welds in a manner that will subject them to the least restraint.

Cracking is rarely experienced in the weld deposit of these alloys. When cracking does occur, it usually appears in the base material. Such cracking is very fine, approximately $\frac{1}{8}$ in. long, and usually transverse to the weld. In cases of extreme restraint, where the welded part might be a spud in a tank shell, for example, the cracking will occur parallel to the weld. However, when the characteristics of these alloys are understood, little or no difficulty is experienced in their welding.

The causes behind these two types of cracking, transverse or parallel to the weld, may be explained as follows:[2]

(1) Cracks in the parent metal, perpendicular to the weld, occur during the deposition of the electrode into the weld joint. At this time, the parent metal is in the process of expanding as a result of heat absorption from the hotter weld deposit. When the parent metal reaches the hot-short range,

stresses set up by this expansion cause small cracks to propagate from the edge of the deposit through the heat-affected zone, which is approximately $\frac{5}{32}$ in. wide.

(2) When fillet welding spuds or other fittings into a tank, or welding other parts having restraint, cracks may appear approximately $\frac{1}{8}$ in. from the weld and longitudinal to the weld bead. This cracking is caused by shrinkage across the weld fillet face and subsequent cracking in the heat-affected zone.

Experience with these superalloy materials has been that they can be welded, but it is necessary to observe the following general conditions to produce satisfactory weldments: (1) To have a minimum of weld restraint; (2) keep the base material at approximately room temperature; (3) to maintain good alignment of joints; (4) use stringer beads.

By the application of these basic principles, the welding problems encountered with high-alloy materials will be minimized.

References

1 W. O. Binder; "Alloys for High Temperature Service," *Iron Age*, Nov. 7, 1946, p. 46.

2 American Welding Society, *Welding Metallurgy*, 2nd Edn., 1952, Ch. 10.

(To be concluded)

Air-Cooled Crucibles for Cold-Mould Arc Melting

FORCED-AIR cooling has been applied experimentally at the U.S. Federal Bureau of Mines Station, Albany, Oregon, to the cold-mould arc melting process used with zirconium and other reactive metals, according to M. M. Kirk, P. C. Magnusson and G. L. Schmidt, in U.S. Bureau of Mines Report, No. 5443. The present commercial technique utilizes a water-cooled, cylindrical copper cup or crucible, into which a consumable electrode is melted by a direct-current arc. The melting is done in vacuum or in a low-pressure noble-gas atmosphere. Severe explosions have occurred in such apparatus, probably caused by entry of water into the evacuated furnace cavity, following accidental piercing of the crucible wall by the arc. Air is markedly safer than water as a cooling agent.

Development work has indicated that a copper crucible with narrow, closely spaced, longitudinal slots in its outer surface represents the best general design, that such units are practicable in sizes corresponding to those of water-cooled units, and that they can be operated at comparable power levels.

It had been surmised that heat transfer from crucible to air stream would be the limiting factor in determining the feasibility of air cooling; hence, three objectives were sought in the design: (1) A large cooling surface, (2) a large mass flow of air, and (3) high turbulence in the air stream. The cooling surface was expanded by using fins on the exterior surface of the crucible. An external jacket confined and directed the air stream, ensuring maximum use of the expanded cooling surface. In general, mass air flow can be controlled by the correct choice of air-supply blower capacity. Narrow width and as-machined surface roughness of slots contributed to air stream turbulence. This was increased further by later herringboning of the fins.

Tests with longitudinally-finned copper crucibles were successful, on the whole. Both consumable and non-consumable melting conditions were maintained regularly for periods of 10 min. or more, with results as favourable as those obtained with water-cooled units. Two principal casualties occurred to crucibles—piercing by the arc and failure of the air hose during a test. This resulted in the ingot fusing to the crucible wall, even though air-flow was partly restored soon after failure of the hose. The crucible was damaged irreparably during removal of the ingot. In neither incident was the safety of personnel or of nearby equipment threatened.

A circumferential-fin crucible and its jacket were built with interleaving fins. The dimensions were selected to provide a narrow passage for air flow between the interleaved fins. It was hoped that highly turbulent air flow would result, which would remove heat readily from the crucible and transfer a significant part of it to the fins of the jacket, which was water-cooled. Test results were disappointing, the initial air flow proved to be unexpectedly low, and during the early part of the test the air flow became even less. It was suspected that longitudinal expansion of the crucible acted to move the fins at the lower end of the crucible closer to the jacket fins, thus constricting the flow of air.

Tests with a stainless steel crucible were also unsuccessful, due to inadequate heat removal and welding of the ingot to the crucible wall. Likely factors were the low heat conductivity of stainless steel, poor heat transfer through the spot welds from crucible to fins, and insufficient fin area. The use of stainless steel as a possible crucible material was abandoned.

Herringboning of the fins was intended to increase the turbulence of the airstream and thereby increase the average heat transfer coefficient; it was tried on two copper and one stainless steel crucible, and the herringboned fins gave better performance in each instance than did straight fins. A significant improvement in heat transfer performance, approximating 25-35 per cent, is indicated.

The longitudinally-slotted copper unit, with the fins an integral part of the crucible body, is believed to be the best design from the standpoints of efficient heat transfer and mechanical ruggedness. The machining of slots is expensive. Copper is a material that can be readily cast, and shapes can generally be produced in this manner at lower cost than by machining. Spin casting of finned crucibles is currently being investigated experimentally. Extrusion is another method that might be feasible.

Other materials more readily machined than copper might also be satisfactory for containing zirconium as it solidifies. This is another approach that might reduce the cost of fabricating finned crucibles. Preliminary tests were made in this laboratory with a shallow, water-cooled aluminium crucible, but these tests were unsuccessful, in that zirconium sponge, when melted, promptly welded to the aluminium.

Correspondence

Correspondence is invited on all subjects of interest to the non-ferrous metal industry. The Editor accepts no responsibility either for statements made or opinions expressed by correspondents whose letters appear in these columns

Too Fast

TO THE EDITOR OF METAL INDUSTRY

SIR,—I have read the item under the heading "Out of the Melting Pot" entitled "Too Fast!" in METAL INDUSTRY for 13 February, page 122, and if in the reference to the surface treatment of magnesium, "Skimmer" means that he believes that the numerous recent reports of work on this subject have not recorded any remarkable achievements, I would certainly agree. Most of the voluminous reports which have appeared over the last few years, both in this country and (chiefly) in the United States of America, constitute a dreary record of uninspired and unimaginative work that has brought singularly little to light. Indeed, most of their findings could have been deduced by a few minutes consideration of the basic chemistry of magnesium, at a considerable saving in time and money and at little loss to science or industry.

Yours, etc.,

W. F. Higgins.

Magnesium Elektron Limited.

INJECTION PRESSURE — METAL TEMPERATURE — DIE TEMPERATURE — CYCLING SPEED

Operational Factors in Die-Casting

By P. P. MOSKVIN

In this article, which has been specially translated for "Metal Industry," by H. K. Barton and Romain Grunberg, the author distinguishes four operational variables as mainly determining the characteristics of diecast components. These are injection pressure; injection temperature; die temperature and injection velocity. The way in which each of these affects tensile strength is discussed and the results are graphed. Approximate means of varying velocity of injection on Polak die-casting machines are suggested.

IN the Soviet die-casting industry cold-chamber machines, in which metal is injected into the die cavity at a temperature generally below the liquidus, are more widely used than "gooseneck" type machines. Among the operational parameters determining the results obtained with this type of machine the principal ones are as follows:— (1) The pressure exerted upon the metal to fill the cavity. (2) The temperature of the alloy. (3) The temperature of the die. (4) The speed of operation (shots/min.).

A high pressure is needed to fill out the cavity completely when producing thin-walled castings, especially when the initial temperature of the metal, as it is ladled in, is below the liquidus.

The actual pressure (kg/cm^2) exerted by the plunger upon the metal in the sleeve is theoretically determinable from the formula:—

$$P = \frac{4\,Pnp}{\pi d^2}$$

where d is the diameter of the plunger in centimetres and Pnp the thrust in kilograms exerted by the ram, which in turn is a function of the line pressure and the ram diameter.

In practice, owing to the mode of regulation of the injection system, the process of compression and the filling up of the cavity are accompanied by a progressive increase in pressure, but the pressure as determined from the above relation is not attained until the end of the injection stroke and, even then, there is always a small loss of head.

Influence of Pressure

The work of G. G. Putsikin has made it possible to demonstrate the influence of injection pressure upon the mechanical properties of die-cast test-pieces produced from the aluminium alloy Al 5 on a cold-chamber machine with horizontal sleeve. The results are depicted in Fig. 1: they indicate that in the injection pressure range between 200 and 800 kg/cm^2 (3,000 to 11,000 lb/in^2), the tensile strength increases with increased injection pressure.

The author has more recently carried out a series of analogous experiments upon test-pieces cut from die-cast components produced in alloy Al 3 on a Polak 900 machine. The curve, over the injection pressure range 200 to 550 kg/cm^2, confirms the positive influence of injection pressure upon mechanical strength.

Influence of Temperature

The effect of variations in alloy temperature, as measured in the crucible of the holding furnace, were determined during the same series of investigations and the results appear in Fig. 2, where tensile strength is plotted against alloy temperature and the curves for both the alloy Al 3, and the alloy Al 5, are given. As may be seen with the latter the tensile strength is highest for test-pieces cast in the temperature range 600°-720°C. (1,100°-1,325°F). For the alloy Al 3 there is a distinct tendency for the strength to fall off with increasing temperature, this already being manifest at a metal temperature of 580°-600° C.

The tendency for the tensile strength to fall with *decreasing* metal temperature, very notable in the curve for Al 5 at temperatures below 600°C. has been explained by G. G. Putsikin as due to the imperfect fusion of successive portions of the metal stream flowing into the cavity. The present author, on the contrary, would attribute the loss of strength, in die-castings produced from metal injected in the semi-liquid state between solidus and liquidus, to an inadequate control of the homogeneity of the metal and the non-observation of certain practical principles in feeding semi-liquid metal to the die-casting machine.

Essential Pre-requisites

In working with semi-liquid alloys it is essential:—

(a) To top up the holding furnace only with small ingots of the correct specification (i.e. not to transfer semi-liquid metal from another furnace — *Trans.*)

(b) To maintain the holding furnace rigidly at the designated temperature and completely exclude sudden temperature changes.

Fig. 1—Influence of injection pressure upon mechanical characteristics: A—flat test-piece cast in Al 3, die temperature 200°-220°C., metal temperature 610°-640°C., thickness of casting 5·5-6 mm. B—flat test-piece cast in Al 5, die temperature 150°-180°C., metal temperature 680°-700°C., thickness of casting 2 mm.

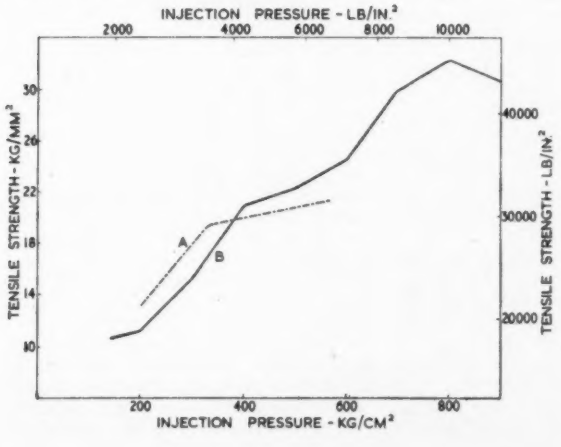
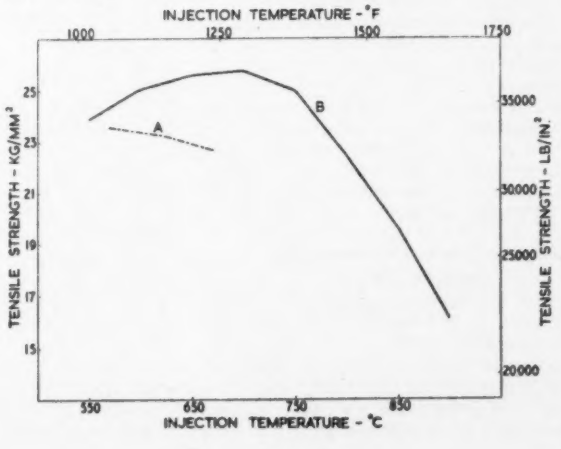


Fig. 2—Influence of injection temperature upon mechanical characteristics: A—flat test-piece cast in Al 3, die temperature 200°-220°C., injection pressure 560 kg/cm² (8,000 lb/in²). B—flat test-piece cast in Al 5, die temperature 150°-180°C., injection pressure 400 kg/cm² (5,700 lb/in²)



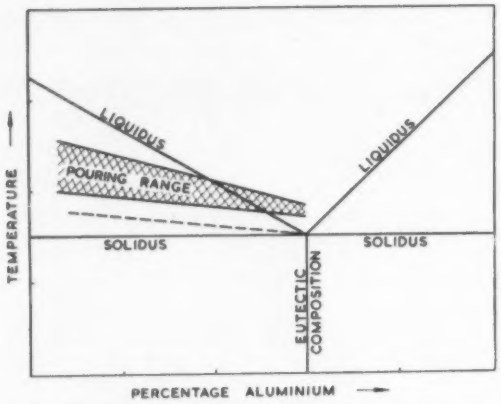


Fig. 3—Practicable casting temperatures for aluminium die-casting alloys shown as a function of their composition ; as the temperature range between solidus and liquicus becomes less, the optimum casting temperature approaches and eventually exceeds the liquidus

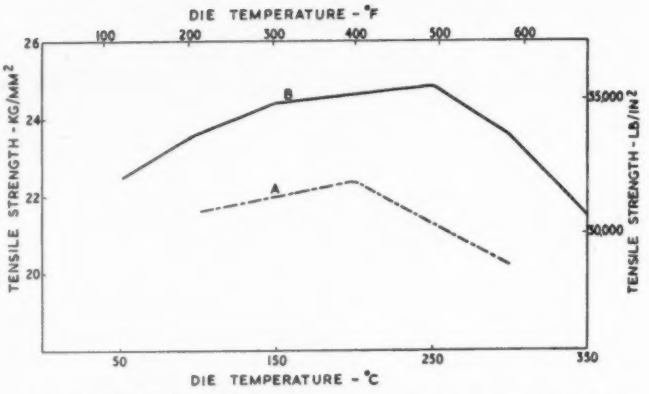


Fig. 4—Influence of die temperature upon mechanical characteristics : A—flat test-piece cast in Al 3, metal temperature 610°-640°C., injection pressure 560 kg/cm² (8,000 lb/in²), thickness of casting 5·5-6·2 mm. B—flat test-piece cast in Al 5, metal temperature 680°-700°C., injection pressure 400 kg/cm² (5,700 lb/in²), thickness of casting 5 mm. approx.

(c) To exclude the possibility of any addition of a different alloy to the melt.

(d) To fill the ladle only from the top 100-150 mm. (4-6 in.) of the melt and to take only from near the middle of the crucible.

(e) To pour the metal rapidly into the sleeve and to inject immediately.

(f) When preparing the alloy initially, to hold specification limits on impurities and avoid overheating when melting alloying additions.

Casting Temperatures

The above factors being taken into account, the author recommends that the actual pouring temperature for all alloys be the lowest at which they will satisfactorily fill out the die cavity. The eutectic alloys (for example, Al 2 should be cast at a temperature about 20° to 25°C. above the freezing point. In the case of alloys having a considerable temperature interval between solidus and liquidus it is recommended that the pouring temperature be a little below the liquidus, the precise temperature necessarily being determined by the section thickness of the component, its complexity, and the volume of metal being injected. In Fig. 3 the stippled area indicates the possible range of variation in casting temperature.

From observations made in working with a cold-chamber machine of Polak type with a vertical metal chamber, it would appear that the lowest possible casting temperature for an alloy of given composition is, approximately, one third of the solidification interval above the solidus for the specified composition. This limit is shown by the broken line in Fig. 3.

Effect of Die Temperature

The influence of die temperature, upon the mechanical strength of the die-casting produced, is illustrated in the graph of Fig. 4. The diminution in tensile strength when die temperature rises beyond about 200°-250°C. is not explicable, as G. G. Putsikin supposes, by a coarsening of the grain structure of the injected metal; it is due to variation in the density of the air which has to be displaced from the die cavity.

Although the density of air diminishes as its temperature rises, its kinetic viscosity increases. Since it is upon the viscosity of the trapped air that the velocity of its passage through the venting channels depends, the effect of raising the die temperature is to slow down the evacuation of the cavity ahead of the advancing metal. Because of this, the structure of the resulting casting is less dense and its strength is diminished, (see translators' notes).

In the author's experiments, the die temperature was measured just before closure on the joint face, at a point near to the cavity edge on the ejector half of the die (the block not containing the sprue orifice), by means of a contact thermocouple. Under these conditions, the superficial die temperature (for the production of die-castings of satisfactory structure) was observed to fall within limits given by the relation:—

$$T_m = 1/3\ T_a + K$$

where T_m = superficial die temperature
T_a = pouring temperature of alloy

and K = a constant which for aluminium alloys = 25°C.

The temperature at any particular point in the die varies during the course of the casting cycle. In practice, one must adopt a rate of operation such that, at each cycle, the accession of heat to the die from the injected metal balances the heat loss to the cooling medium and to the ambient air.

Velocity of Injection

The influence of injection velocity has not received adequate attention, largely because in Russian machines there is no arrangement for measuring plunger speed or of regulating it. However, on both Krasnaya Presnva (the Soviet equivalent of the Czechoslovakian Polak) and Polak machines it is possible, by the aid of a needle-valve to vary the speed of injection even though one cannot measure plunger speed nor set it to a predetermined value. An approximate means of adjustment to injection speed may, nevertheless, be obtained by utilizing the angular graduations which are provided, on the most recent Polak machines and which permit the number of turns of the screw controlling the needle-valve (in the hydraulic circuit of the injection ram — *Trans.*) to be checked.

On machines having a horizontal injection ram it is possible to measure the speed of injection directly, adopting an arrangement devised by the automobile plant "Stalines". It is not recommended that high speeds of metal injection be adopted, for the plunger then traps a great quantity of air as it advances and forces this air into the alloy. It has been shown necessary in practice to cut down the injection velocity to a minimum when producing die-castings of heavy section; for components of great size, and for those of thin section, the velocity of injection must be increased.

Translators' Notes

I. *Influence of Air Viscosity upon Injection Velocity.*

Although the increase in viscosity noted by Moskvin is real enough, it is quite inadequate as an explanation of the phenomena. The velocity of metal influx is, of course, determined by the difference between the plunger pressure and the back pressure built up in the cavity as the contained air is compressed. When for any reason the air cannot escape freely through the vents the back pressure is accordingly increased and the velocity of influx falls, though the actual hydrostatic pressure upon the molten metal is *greater than before.*

The operating temperature of a die-casting die is the outcome of a complex of factors operating interdependently, as is evident from the well-known "thermal equation to a die-casting die"

TABLE I—SOVIET RUSSIAN DIE-CASTING ALLOYS (Al-BASE)

Designation	Composition (per cent)					
	Si	Cu	Mg	Mn	Zn	Al
Al 2	10-13	1·5-3·5	0·2-0·8	0·1-0·4	10-14	Bal.
Al 3	4-6		4·5-5·5			,,
Al 13	0·8-1·3					,,
Al 11	6-9					,,

due to H. K. Barton (METAL INDUSTRY (Lond.) December 10, 1948), and the effect of increasing the cavity temperature — by whatever variation of the terms of the equation — is to reduce the viscous shear stresses in the initially projected skin (H. K. Barton, "Injection of Metal into Diecasting Dies." *Machinery* (Lond.) March 30, 1944). In consequence, a shell of greater area is laid down, occluding a greater length of the die-parting perimeter. The vents, except any immediately adjacent to the gate, are thus rendered ineffective early in the injection phase and filling is progressively slowed down. There is thus more time for entrained air to escape from the inflowing metal. As heat from this turbulent mass diffuses through the shell, the latter recalesces with a coincident increase in grain size which, as proposed by G. G. Putsikin, results in a diminution of mechanical strength. The causative agent adduced by Moskvin is irrelevant in the working conditions of a die-casting die, and his criticism of Putsikin untenable.

II. *A note on Russian Die-casting Alloys.*

In the Soviet die-casting industry, alloys of aluminium are much more important than zinc-base alloys. The latter seem to be used only for small to middle-sized components of automobiles. To some extent, this reflects materials availability; the zinc resources of the U.S.S.R. are not great. Moreover, the Russians have only very recently thought it worth while to put into production a "four nines" quality, so that the essential basis for developing a high-grade zinc die-casting alloy has been lacking. The one standard zinc alloy has a top limit of 0·015 per cent, as compared with 0·003 per cent in Zamak zinc alloy ingot and 0·005 per cent in Western European specifications for die-cast components.

There are several aluminium die-casting alloys in common use in the U.S.S.R. most of them roughly paralleling U.S. and British Specifications. The most important are listed in Table I. Al 2 is the eutectic alloy with good castability and high corrosion resistance. Its main disadvantage is a tendency to "solder" to the cavity surface. Al 3 has good flow characteristics but less satisfactory corrosion resistance; its tendency to solder is less than that of the eutectic. Al 5 is a general purpose alloy, suitable for sand and gravity castings as well as (pressure) die-castings. Al 13, with 5 per cent magnesium, represents a type of alloy which has not been widely exploited; in Britain Fry's Diecastings Ltd. die-cast a 6½ per cent magnesium alloy, and in the U.S. the 8 per cent magnesium alloy die-cast by the Doehler-Jarvis Corporation, under their trade name "Do-Lite", has won a limited acceptance. Flow characteristics are poor and demand high injection pressures, but the resistance to corrosion is excellent. "Do-Lite" takes a decorative anodized finish, but it is doubtful whether Al 13, containing roughly one per cent silicon, is comparable in this respect. LM 10 (not used for die-castings in Great Britain) is the comparable B.S. alloy. Al 11, with its high zinc content, is reported to be well suited to the production of small and thin-sectioned components not calling for great corrosion resistance. Aluminium die-castings of about forty inches diameter and some weighing up to 20 kg (44 lb.) are reported to have been produced, at least on an experimental basis; this is comparable with advanced U.S. achievements, though it is stated that pieces of this size are cast on horizontal-platen machines, a method which is almost certainly better adapted to further increases in size than the now general vertical arrangement to which the Doehler "72 in." design adheres.

Men and Metals

A recent appointment by Black and Decker Ltd. is that of **Mr. F. A. Field** as industrial contracts manager. Mr. Field joined the company as district manager in 1939, with his headquarters at Leeds, and in 1953 he was appointed U.K. sales manager for the company. In 1957 he left the company to join the Eutectic Welding Alloy Company Limited as managing director, but has recently relinquished that office.

Two new appointments to the outside sales staff of Geo. Salter and Company have just been made. **Mr. Brian M. Morgan** will represent the company in the East Midlands, and the southern counties (North of the Thames) and East Anglia will be represented by **Mr. I. C. Stevenson.**

It has been announced that **Mr. Ben Endlar** has joined the board of directors of John E. Moore Limited, of Yeadon, Yorks.

An announcement from Tube Investments Limited is to the effect that **Major-General Sir Francis de Guingand,** K.B.E., C.B., D.S.O., and **Mr. E. L. Burton,** B.A., A.C.A., have been appointed to the board of the company. Since 1949, Sir Francis has been in charge of T.I.'s interests in South Africa. Mr. Burton will continue to be secretary of the company.

Recently, **Mr. Laurence Malec,** M.B.E., A.R.Ae.S., joined the Solartron Electronic Group Limited, and has been appointed managing director of Solartron Radar Simulators Limited.

At the beginning of next month, **Mr. John Clifford Duckworth,** B.A., F.Inst.P., A.M.I.E.E., F.Inst.F., will become managing director of the National Research Development Corporation. This is a statutory appointment made by the Board of Trade under the Development of Inventions Act, 1948. **Mr. Dennis Hennessey** has been appointed by the Corporation to a new post of deputy managing director. He was formerly a Principal Patents Officer at the Ministry of Supply.

By order of H.M. The Queen in Council, **Sir John Cockcroft** has been appointed a member of the Court of the University of London.

As a representative of the Guild of Graduates, **Dr. W. I. Pumphrey,** D.Sc., has been elected to the Court of Governors of the University of Birmingham. Dr. Pumphrey is manager of the research department of Murex Welding Processes Ltd.

Director of research for the last four years, **Mr. B. Eichler** has been appointed to the board of General Refractories Limited. Mr. Eichler joined the company in 1940 and was chief technologist for several years.

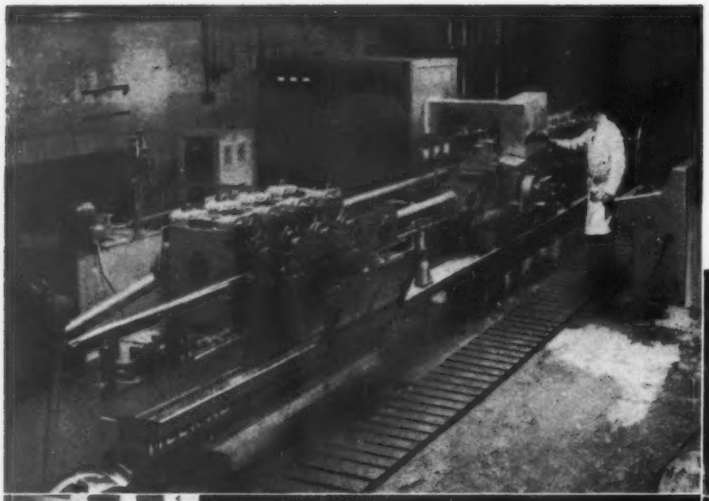
The Society Medal of the Society of Chemical Industry, which is awarded not more than once every two years for conspicuous services to applied chemistry or to the Society, has been awarded for 1958 to **Dr. Francis H. Carr,** C.B.E., F.R.I.C., D.Sc.

Aluminium Casting Alloys

FOLLOWING the formation last year of the Association of Light Alloy Refiners and Smelters Ltd., this body has now issued its first publication, "The Properties and Characteristics of Aluminium Casting Alloys." Based on the original ALAR data sheets, this smaller edition contains all the data included in them and also deals with nine standard alloys not included in the earlier publication. In addition to specification requirements it gives typical properties and information on the physical, foundry and other characteristics of the alloys, as well as a section on heat-treatment and a guide to the selection of alloys.

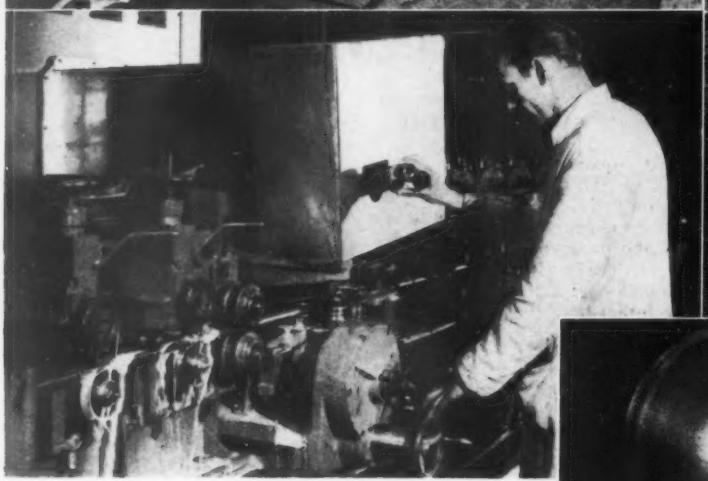
It is available from the Association at 3 Albemarle Street, London, W.1, price 4s. 6d.

Welded

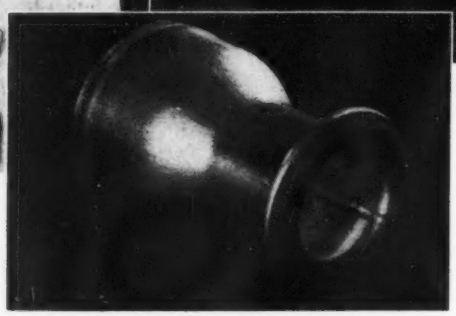


Left : The combined tube forming and welding machine, showing the welding head, operating console and straightening section

Below : General view of the tube mill, showing the entry of strip into the forming roll sequence



Above : The welding head with the squeeze rolls, and, on the left, scarfing tools

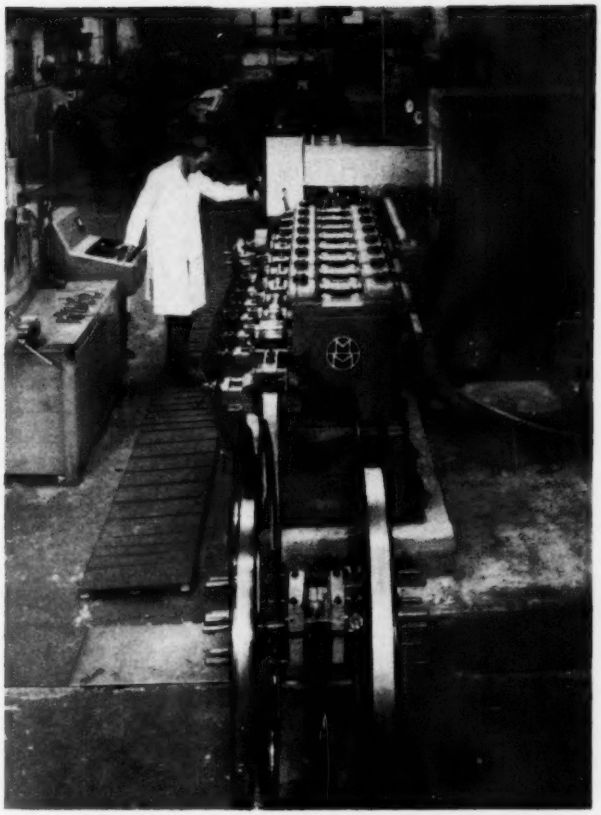


Right : Sample of welded light alloy tube, after drift test

Close-up of the tube passing beneath the welding contacts and through the squeeze rolls

After leaving the squeeze rolls, the welded tube enters two sets of scarfing tools, where flash is removed

Aluminium Tube



A NUMBER of efforts have been made towards the development of a high production mill for the roll forming and welding of aluminium tube from strip material, and a recent installation by Elm Engineering Limited, a member firm of the Antiference Group, indicates how far progress has been made in this direction. High-frequency welding is used, and the majority of the production goes to Antiference for use in television aerials and tubular furniture.

Briefly, the method of production involves the passage of strip through several stages of rolls until it becomes an almost closed circle. Two contact shoes are used to transmit high frequency current along either side of the almost closed seam of the tube. Heating of the metal occurs only at the edges of the strip, and when these are forced together by two pressure rollers a forged weld results.

The new plant combines two units —a tube forming mill and a high frequency resistance welding machine. The latter has been developed by the New Rochelle Tool Corporation of New York, and the process is known as the Thermatool. It is capable of production welding speeds in excess of 250 ft/min., this high rate being made possible by the concentration of heat at a localized area, thus reducing metal deformation. Speeds of up to 400 ft/min. have been obtained with light gauge tubes, but normal operation is around 240 ft/min. for the sizes produced.

Aluminium strip employed for the tubes produced by this company covers the range 14-22 S.W.G., and tubes may range from ½ in. to 1½ in. o.d. Strip is fed into the mill from a coil carrier, which carries two coils and is mounted on a stand capable of being rotated, thus permitting one coil to be loaded on to the carrier while another is feeding strip to the mill.

Eight pairs of forming rolls progressively deform the strip as it passes through them. It then enters the seam guide, which determines the weld gap, and immediately passes under the welding head that supplies high frequency current to two contacts, one at either side of the gap. Situated close behind the contacts, two squeeze rolls close the gap, current thus flowing from the contacts to the point at which the edges of the metal are forced together by the rolls; it is at this point that the combined heat and pressure produce the weld joint.

The tube next passes through two scarfing tools, all external flash being removed. Four further roll stages straighten and size the tube, and it is then cut to the required length by flying guillotine shear, and deposited on an automatic discharge rack.

In the tube mill, forming rolls are of high carbon-high chromium steel, and the squeeze rolls are of phosphor bronze. Wire wool cleaning pads are employed to remove any aluminium pick-up that may occur.

The welding head has a high-frequency transformer, giving an input of 300 kVA and 50 kW. Current is fed to the welding contacts at 100 V via a pair of water-cooled leads. The contacts themselves are also water-cooled, and each of them can quickly be replaced, the service life being about two weeks. The power for the welding unit is derived from a high frequency valve oscillator with an output of 50 kW at 450 kc/sec. Where higher mill speeds and greater wall thicknesses are demanded, larger generators would be necessary.

So far, the alloys that have been used for production of tube in this mill have been NS 3, NS 4, NS.5, and a 1 per cent magnesium alloy. The heat-treatable alloys have not as yet been tried. Micro-analysis has shown that the weld is truly homogeneous. Since the layer of plastic metal at the edges being welded is only a few thousandths of an inch thick, the crystal structure of almost all of the parent metal is unaffected, since most of the metal which has been heated is forced out into the scarf (which, on the outside of the tube, is subsequently removed during straightening operations).

Independent laboratory tests on the tubes have shown by micro-analysis that the weld point is truly homogeneous, and the tubes may be formed, shaped, pierced, polished, and even anodized.

Nickel Alloys

FOR its fiftieth issue, "Wiggin Nickel Alloys" has as its theme the scope of the Wiggin organization, its products and their properties, and the wide range of uses to which they are put throughout industry. Among the materials dealt with visually and in text are the Nimonic series of heat-resisting alloys; corrosion-resisting materials such as nickel, Monel, Inconel, Corronel, and Ni-o-nel; the Brightray family of electrical resistance alloys; and materials with special physical properties such as the Nilo series and JAE metal. Special sections illustrate recent production developments and the products of modern fabrication methods.

Issued free of charge, it is available from Henry Wiggin and Co. Ltd., Thames House, Millbank, London, S.W.1.

Research Progress

Precipitation in Nickel-Base Alloys

BY RECORDER

IT is only to be expected that considerable attention should have been given in recent years to precipitation in Nimonic-type alloys. Taylor and Floyd[1] showed that the improvement in the high-temperature strength of the 80-20 nickel-chromium alloy by the addition of aluminium and titanium was associated with a precipitate based on the ordered Ni_3Al phase. In a recent Paper,[2] Manenc reports the results of a detailed investigation by X-ray methods of precipitation in a typical Nimonic of per cent composition chromium 19·5, aluminium 1·5, titanium 2·4, and the following simple binary or ternary alloys prepared from pure materials, namely, nickel+7·8 per cent aluminium, nickel +2 per cent titanium+5 per cent aluminium, nickel+7 per cent titanium +2 per cent aluminium, nickel+20 per cent copper+6 per cent aluminium, nickel+7 per cent silicon, nickel+30 per cent copper+5 per cent silicon, nickel+7·5 per cent molybdenum+5 per cent silicon.

Some ingots were cut into sections 5×5 mm. and homogenized for 65 hr. at 1,080°C., quenched and then rolled, but the more fragile alloys were homogenized by heating in vacuum to about 50°C. of the solidus, and these could then be rolled to 1 or 1·5 mm. without serious cracking.

Three X-ray methods were employed: (1) Debye-Scherrer technique with monochromatic copper or chromium $K\alpha$ radiation; (2) observation of diffuse scattering near Bragg spots by double reflection; and (3) small angle scattering of monochromatic copper $K\alpha$ radiation. The observations were supplemented with micrographic work by Madame Bückle and G. Lenoir.

The results obtained by the various methods were consistent with the interpretation that all the alloys were, after solution heat-treatment and quenching in water, composed of a single phase, namely, a face-centred cubic super-saturated solid solution. On subsequent isothermal ageing at various temperatures, depending on the composition, the phase went through a pre-precipitation stage as indicated by diffuse scattering of X-rays by method (2) or (3) above, and the change was associated with appreciable hardening.

Two types of diffuse scattering were observed: (1) from the alloys nickel +7·8 per cent aluminium, nickel+7 per cent aluminium, nickel+2 per cent titanium+5 per cent aluminium, nickel +7 per cent titanium+2 per cent aluminium, nickel+30 per cent copper +5 per cent silicon, nickel+7·5 per cent molybdenum+5 per cent silicon, the scattering appeared as sharply resolved spots near the Bragg reflection spots of the matrix. This effect is interpreted as the beginning of precipitation on planes parallel to {100} planes of the matrix forming plates of enhanced solute concentrations in coherence with the matrix lattice. For the above alloys a difference of more than 0·5 per cent in parameter was observed between precipitate and matrix at 700°C., while scattering of type (2) from the Nimonic alloy and nickel+7 per cent silicon and nickel +20 per cent copper+6 per cent aluminium was not resolved, and for 100 reflections was principally in the radial direction of the Debye-Scherrer rings with no circumferential scattering. The effect is considered to be due to the formation of cubic zones of solute concentration with edges parallel to <100> axes of the matrix and the interpretation is supported by the appearance of precipitate in specimens heat-treated at an elevated temperature, when the difference (either positive or negative) in parameter between precipitate and matrix is about 0·1Å, that is, less than half what it was for the alloys yielding plate-like zones of segregation.

In discussion of the results of his investigation, the author considers that the evidence supports the theory of age-hardening as developed by Guinier for aluminium alloys. This is purely an academic point; what is important is that the investigation is a fine piece of systematic work by which it is established that hardening and strengthening are mainly associated with the strongly coherent stage of pre-precipitation. The form of the initial zones of solute concentration depends on the parameter difference between precipitate and matrix in equilibrium condition in accordance with Nabarro's predictions.[3] The question may legitimately be raised: which form of pre-precipitated zone is the more effective? It may be significant that for the selected Nimonic the zones are of cubic form.

References

1. A. Taylor and R. W. Floyd; *J. Inst. Met.*, 1951, **52**, 577; *ibid*, 1952 **53**, 25; *ibid*, 1952, **53**, 451.
2. J. Manenc; *Acta. Met.*, Feb., 1959, 7 (2), 124.
3. F. R. N. Nabarro; *Proc. Phys. Soc.*, 1940, **52**, 90.

Soldering Process for Armatures

A SPECIALLY designed and constructed soldering system has resulted in a 50 per cent reduction in soldering time for traction motor armatures at General Electric's Apparatus Service Shop in Chicago, Illinois.

In soldering armature coil leads to commutator bars for traction motors, more than 50 connections can be soldered in one operation within 10-15 min.

The soldering equipment consists of a base holding the soldering ring, a reservoir pot for the solder, a cylindrical displacement weight, electric immersion heaters in both the reservoir and the soldering ring, and controls for the heaters and weight.

Pure tin solder is melted in the reservoir pot by three over-the-side immersion heaters rated 1,500 watts each. For actual soldering, the molten solder is passed through a trough to four 1,000 watt cast-in immersion heaters in the soldering ring. Amount and rate of solder flow in the ring is controlled by lowering or raising a cylindrical displacement weight in the reservoir. Motion of the weight is controlled by an operator.

Used primarily for traction motor armatures, the soldering system accommodates armatures of various sizes with the use of a series of telescoping adapters. The adapters are inserted in the soldering ring. Before the soldering operation is started, the armature is preheated to 300°F. Whiting is applied to the commutator to prevent solder from adhering to surfaces. The commutator end of the armature is then lowered into the soldering ring and the connections are automatically soldered.

Obituary

Mr. T. Platt

IT is with regret we record the death of Mr. Thomas Platt, chairman for many years of Thomas Platt and Sons (Widnes) Ltd., iron and non-ferrous founders.

Industrial News *Home and Overseas*

Factory Equipment Exhibition

This year's exhibition is to be held from April 7 to 17 at Earls Court, London, and the keynote will be "efficiency and expansion." More than 300 exhibitors will show the best of their equipment relating to materials handling, storage, heating and steam raising, ventilation and air conditioning, heat and sound insulation, product finishing, and instrumentation.

There will also be workshop and packing equipment, production and stock control, drawing office equipment, safety and welfare, and, in addition, special attention will be focused on various types of equipment suitable for the implementation of the Clean Air Act. In the associated heat and sound insulation exhibits there will be materials and systems to meet the regulations of the Thermal Insulation (Industrial Buildings) Act. There will also be conferences addressed by leading experts in these subjects.

Enquiry from India

From one of our subscribers in Madras, we have an enquiry for one ton of pure copper, 99·7 per cent or higher, and one ton of zinc (best quality, for galvanizing) against their import licence. Offers with prices and export terms should be made as soon as possible to the editorial offices of this journal.

New Divisions Established

Following their policy of converting to the most modern heat-treatment equipment, and of offering to the British engineering industries a most comprehensive range of services, **Expert Heat Treatments Ltd.** have now established several new divisions of the company, including the following:

A heavy shop which can take several furnace loads of up to 5 tons and with controlled temperature of over 1,250°C.; a tool and high speed steel section, together with martempering facilities having sufficient capacity to handle all normal size tools and dies; a light alloy section consisting of four forced-air circulation, close temperature control electric furnaces for standard normalizing, solutionizing and annealing work, together with a large mechanically-charged horizontal furnace for precipitation treatment; and a controlled atmosphere furnace section in which is installed the latest Efco carbo-nitriding plant and Wild-Barfield gas-carburizing equipment.

Tinplate in Coils

News from the **Steel Company of Wales Ltd.** is that the first coils of tinplate ever to be produced in this country have recently been made at the company's Velindre works. So far about 100 tons of strip tinplate in coil form have been despatched to customers.

When the No. 2 electrolytic tinning line was installed at Velindre it was equipped with twin recoilers situated immediately following the drive bridle. These have now been brought into use and are ready to supply the demand for coils, which is expected to increase as more users of tinplate equip their works with coil handling equipment. At present only a few companies appear to have the necessary facilities to handle coils, but it is understood that others are planning to include such equipment in proposed new plants.

Our photograph on this page shows some of the tinplate in coil form at the Velindre works. Coils which at present weigh up to seven tons, according to the customers' needs, are carefully wrapped in corrugated bituminous paper before being despatched from the works.

Cathodic Protection

Produced in conjunction with W. G. Pye and Company Ltd., the Cathodic Protection Division of **F. A. Hughes and Company Ltd.** have issued a leaflet describing the "Guardion" corrosion voltmeter. Although the instrument was designed in the first instance for use with cathodic protection projects, ancillaries such as miniaturized half cell electrodes have been specially produced in conjunction with the instrument, and there have already been suggestions that it will fulfil a very useful function as a measuring instrument for various transistor applications.

Industrial Oil Burners

A new range of industrial oil burners has recently been introduced by **Swinney Brothers Ltd.** These burners are of the proportioning low pressure air type, and will be known as Swinney "Moduflame" burners.

Control of the output of the burners is effected by movement of one lever, either manually or by automatic control, and the air/fuel ratio is maintained constant throughout the operating range. Output of each burner can be varied through a turn down range of about $4\frac{1}{2}$ to 1.

When applied to an industrial furnace (e.g. a forging furnace) all the air for combustion, except for a small amount induced around the burner nose, is normally passed through the burner. This air is supplied by a fan at pressures of between 20 in. and 30 in. W.G., while the oil pressure required is of the order of 10 lb/in^2. Maximum burner outputs with all the combustion air passed through the burner range from approximately 6 to 40 gal/hr.

For boiler firing the burners may be used in the way described above or, alternatively, in conjunction with an air register, in which case the burner outputs are increased by about 200 per cent, making the maximum outputs of the range from approximately 18 to 120 gal/hr.

A New Company

It has been announced by **John E. Moore Limited** that a new company has been incorporated with the title of Aluminium Ingot Makers Limited to take over and develop their aluminium ingot, stick and pellet manufacturing and marketing. The policy of the new company will be to concentrate its production on top-grade alloys for existing customers and to follow a controlled expansion programme.

The directors of the new company are Mr. Richard Hopkins, Mr. Ben Endlar and Miss Kathleen Bailey, and the company will commence active trading at the end of this present month.

Methane Importation Scheme

One of the largest aluminium tanks in this country is the 90,000 ft^3 insulated aluminium tank constructed by the **A.P.V. Company Ltd.** for the North Thames Gas Board for the storage of liquid methane at −260°F. A 2,000 ft. insulated aluminium pipeline, 10 in. in diameter, conveys the liquid methane from the ship to the storage tanks on the Gas Board's site at Canvey Island, Essex, chosen for the Methane Importation Trial scheme.

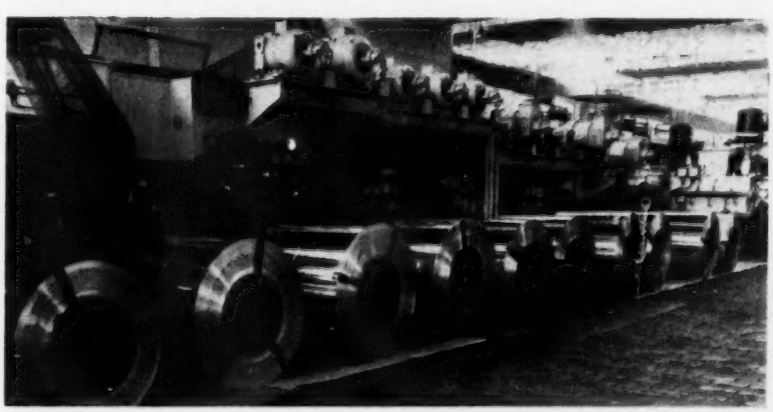
The whole project, of tank and pipeline, is considered by the company to include probably the largest amount of fully radiographed aluminium welding ever to be executed on site in this country.

Firth Company Expands

A new two-storey factory built by the **Firth Company Ltd.,** Warrington, to replace an old mill destroyed by fire in December, 1957, is now ready for occupation. With its wide unobstructed span and modern construction, it will allow the company to increase production of its existing range of wire products, and to enter new markets.

The new building is of reinforced

Electrolytic tinplate in coil form which is now being produced for the first time [in this country, at the Velindre works of the Steel Company of Wales Limited



concrete construction, and the ground floor will be occupied by heavier machinery, including new plant for the production of barbed wire. On the first floor will be installed new straightening and cutting machines, new winding and coiling plant, and ancillary machinery for wire products.

To guard against the possibility of corrosion by acid fumes and moisture from nearby processing plants, all steelwork and exposed concrete has been treated with H.S.56 acid resistant paint, a product developed by British Lead Mills Ltd.

Space Exploration

It is learned from the **Institute of Metals** that the 1959 May Lecture will be delivered by Professor F. Hoyle, F.R.S., on "The Scientific Uses of Space Exploration."

The meeting will be held in the Lecture Theatre of the Royal Institution, Albemarle Street, London, W.1, on Tuesday, April 14, at 7 p.m. Visitors will be welcome and tickets of admission are not required.

Annual Dinner

Some 120 members and guests of the **Foundry Trades' Equipment and Supplies Association Ltd.** attended the annual dinner of the association, which was held recently at the Savoy Hotel, London. The chair was taken by the President of the Association, Mr. Gavin C. Paterson, and the guest of honour was Mr. A. E. Peace, President of the Institute of British Foundrymen, who proposed the toast to the Association.

Among the guests present were Mr. P. B. Higgins (President of the Association of Bronze and Brass Founders), Mr. D. E. B. Barnard (President of the London Branch of the Institute of British Foundrymen), Mr. N. P. Newman, J.P. (President of the Joint Iron Council), Dr. C. J. Dadswell (chairman of the British Steel Founders' Association), Mr. R. Scott (President of the National Society of Master Patternmakers), and Mr. G. W. Illsley (Master of the Worshipful Company of Founders).

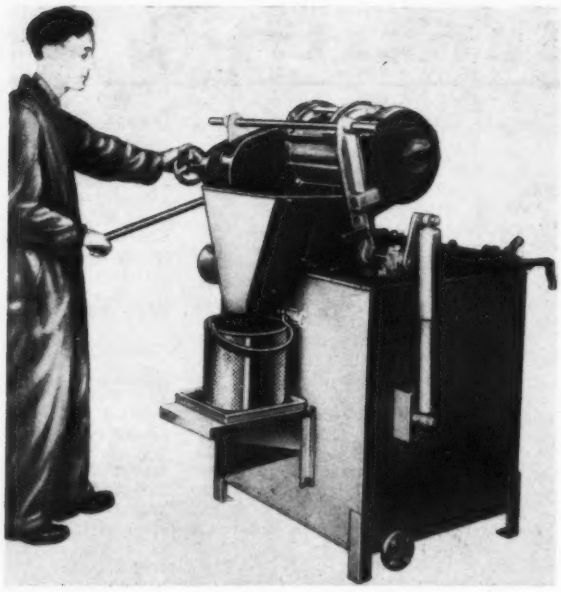
U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange warehouses fell by 667 tons and were distributed as follows at the end of last week:—London 5,541 tons, Liverpool, 5,411 tons, and Hull 1,230 tons. Stocks of refined copper rose by 850 tons, and were distributed as follows: London 2,047 tons, Liverpool 3,170 tons, Birmingham 225 tons, and Manchester 2,625 tons.

Exhibiting in London

One of the most interesting exhibits at the Electrical Engineers Exhibition, which is opening in London next Tuesday, will be that of **W. Canning and Company Ltd.**, whose principal unit on view will be the "Numinik" plating barrel.

This unit has all the advantages of the successful "Minik" barrel from which it was developed, plus the exclusive feature of a swing-out barrel, which eliminates the need for an overhead hoist. The swing-out barrel is counter-balanced for easy operation and the pivot mechanism is fitted with a pneumatic damper which gives smooth action and a steadying control when the loaded barrel is lowered into the solution. "Numinik" barrels are for depositing most solutions other than chrome, and have a capacity of three gallons of articles. This new unit is an outstanding addition to the Canning range of high production plating barrels.



The "Numinik" plating barrel being shown by W. Canning and Company Ltd., at the Electrical Engineers Exhibition in London next week

Also exhibited by the company will be a display featuring "Cub" portable plating barrels. The three barrels which make up this range are easily portable and are for use in any still vat. General exhibits on the stand take the form of display panels showing photographs of automatic plating and polishing equipment, together with components finished in various solutions applicable to the electrical industry. These include specimens of copper, silver, zinc, cadmium, nickel, and chrome plated components.

Theft of Metal

It is reported that the following items were stolen on Sunday last from Ilford Wharf, Roden Street, Ilford, Essex:—(a) Fordson all-steel tipping lorry, No. MTW114, maroon colour, top half of cab light red, black wings, name on cab door L. Watkinson and Sons (hired vehicle).

(b) Material as follows:—No. 2 copper wire in bags, estimated weight two tons; two drums and sacks of white metal dross, bags of heavy tinned copper and commutators, bright tinned copper wire, bright untinned copper wire, No. 2 hanked copper wire, estimated weight one ton.

Any member of the industry able to give any information relating to this theft is asked to communicate with Mr. P. T. Kendrick, J. Kendrick and Sons Ltd., Ilford Wharf, at the address given above.

I.C.I. Exhibits

Three of its divisions will be represented on the stand of **Imperial Chemical Industries Limited** at the Electrical Engineers Exhibition next week. The Metals Division will be showing platinized titanium—non-consumable anodes for various electro-chemical processes. These anodes find two important uses in the production of chemicals in electrolytic cells and in the cathodic protection of steel structures. Anodically protected titanium for use in severely corrosive conditions will also be displayed. Examples of aluminium alloy busbar and busbar jointing compound and copper busbar will also be shown.

I.C.I. silicones form the basis of the Nobel Division's exhibit, while the theme of the Plastics Division will be "I.C.I. Plastics for the Lighting and Electrical Industries."

Street Lighting Columns

A competition for the design of aluminium street lighting columns has been announced by the **Aluminium Development Association,** which feels that the time is ripe to encourage the evolution of good designs for such columns and accordingly has organized this open competition for entry by lighting specialists, architects, industrial designers, engineers, and other individuals or groups.

The competition is for the design of either a 25 ft. high column for group A—trunk road lighting; or a 15 ft. high column for Group B—non-trunk road lighting. The association offers three prizes of £250, £100 and £50, with an additional student's prize of £75.

Principal details of the competition, including the names of the three assessors, are given, and regulations and conditions, with specifications and design requirements, are set out in a 24-page booklet issued by the association. The closing date for receipt of entries is July 1 next.

Packing of Metal Parts

After a series of harsh and intensive tests, Palfsacks, the multi-wall paper sacks made by **William Palfrey and Co. Ltd.**, have been found to be an ideal container for packing certain metal parts and slugs. These sacks, which can be used for export distribution as well as for the home trade, are of either 3-ply or 4-ply construction. The sacks hold up to 3,000 metal slugs each, and weigh between 40 lb. and 60 lb. when filled. The filling is carried out by conveyor belt or by manual application, via a chute. The sacks are sealed by industrial stapling, or in some cases by the simple expedient of bunching the sack at the mouth and securing it by wire ties or sisal.

We understand that among the first

users of these sacks are such companies as the Northern Aluminium Co. Ltd., Enfield Rolling Mills Ltd., John Dale Ltd., and others. These sacks are stated to take up a minimum of storage space and are easy to handle.

Annual Conference

Harrogate is the venue this year of the twelfth annual conference of the **Institution of Plant Engineers,** and this event will be the occasion of a number of authoritative Papers of wide scope and interest. The conference will open on May 6 and close on May 8.

Among the Papers to be presented at this conference will be one on "Management in Plant Engineering," by Mr. P. Mayne, M.A. M.I.Mech.E. (technical director of the Billingham Division of I.C.I.), and another on "The Value of New Materials and Techniques in the Solution of Engineering Problems," by Mr. John Leyland, M.Sc., M.I.Mech.E. (head of the engineering section, central research department, Unilever Ltd.).

A Luncheon Meeting

On Tuesday, March 24 next, a luncheon meeting for members of the **Metal Finishing Association** in the Birmingham area has been arranged. The venue is the Farcroft Hotel, Handsworth, at 12.30 p.m. A prominent guest speaker has been invited and the subject of his address is to be "The Birmingham Traffic Plan."

Bronze and Brass Ingot Manufacturers

ON Tuesday last, at the Queen's Hotel, Birmingham, a general meeting of the British Bronze and Brass Ingot Manufacturers' Association was held, under the chairmanship of Mr. F. Baugh, President of the association.

Following the reading of the minutes of the last general meeting, the President presented his report, in the course of which he said: "The period has been characterized by a low level of trade and, in consequence, intense—often crazy—competition and unprofitable price levels. There have also been determined attempts by the scrap merchants to export scrap at the expense of manufactured products.

"We have also been very concerned by the revision of B.S.S.1400—Specifications for Copper-Base Alloy Ingots—and many other matters of great importance to our trade. These matters have at times caused us considerable anxiety, and we have met on many occasions during the twelve months to discuss and act in what we consider are the best interests of the trade.

"We are all very conscious of the extremely low level of prices, and margins, at which we have had to work for the past year, and particularly the last six months. This situation has caused us all considerable anxiety and many feel it cannot continue for long, as business is generally so very unprofitable. We can only hope that a general revival of trade will not be long delayed to enable more of our productive capacity to be put to work and to restore more normal conditions and more reasonable margins.

"It is understood to be the policy of H.M. Government to remove restrictions on trade as far as possible. They do not propose at present to free entirely the export of ingots, but they have ceased to operate price control and the quota system, although every export order must have a licence, the application for which is carefully considered, and a close watch is kept on the specification of the material shipped. The Association has been consulted by the Board of Trade about all these matters. In view of the difficulty of enforcing the price control, we did not oppose its abandonment; but we would have liked to keep the quota system, knowing from bitter experience how large overseas demands can arise without warning and metal stocks in this country be depleted. The export of ingot forms an important part of our members' trade, and helps to employ labour and the ingot manufacturing plant built up during the war years. I am sure the large figure of unemployed in the country to-day is a matter of concern to all of us, both on the human as well as the economic account and, therefore, we would like to see our export trade preserved.

"You all know that the Scrap Merchants' Association have been agitating for some time for permission to export non-ferrous scrap. It is somewhat amazing, and, we think, somewhat short-sighted, to find them working against the interests and wishes of their customers, the home consumer. Some months ago permission was obtained to export a considerable tonnage of manganese bronze scrap. When this became known we protested most vigorously, with the result that the licences were suspended. They have since been released, but in the end only a small tonnage has been taken up. We have shown that there is a good market for this material in this country, and the Board of Trade have agreed to consult the Association before making changes in the licensing arrangements. We await the decision of the President of the Board of Trade, but shall do all we can to make clear the facts of the situation. I am happy to say we are exchanging views on this matter with other consumer interests, and I would express appreciation of the attitude of the Board of Trade officials, who are always ready to hear our case on this and any relevant subject.

"Reference was made to the revision of B.S.S.1400 last year. It is really a Technical Committee matter, but is so important that I feel I must make reference to it; the Technical Committee feel that founders generally do not appreciate what the general raising of physical properties and limiting elements will mean to them in direct cost of materials and in laboratory control. We fully back the Technical Committee's proposals to give publicity to these matters.

"Although we are passing through difficult times, these do show the great value of being united in a trade association; looking back on the problems we have had to face, it would be unthinkable if there were no organization through which the trade could act in defence of its rights, and if such matters were to go by default. I, therefore, thank you for your support and look confidently for its continuance, especially for my successor."

After matters arising from the President's report had been discussed, the report of the technical committee was presented, in which details were given on the subject of the B.S.S.1400 revision, the analysis and sampling of copper alloys, hard spots in manganese bronze, and melt quality tests.

Following this meeting, the thirteenth annual meeting of the Association was held and after the minutes of the previous meeting had been read, and the statement of accounts presented and adopted, the vacancies on the Council were filled by the re-election of the four retiring members, as follows:—Mr. R. Anderson, Mr. F. Baugh, Mr. E. Josephs, and Mr. W. E. Laybourne.

It was then proposed and seconded that **Mr. J. H. Barwell,** J.P., be elected as President for the ensuing year, and this was carried unanimously. **Mr. T. C. James** and **Mr. J. N. Cohen** were then elected as vice-presidents. Re-elected as secretaries were Heathcote and Coleman.

Forthcoming Meetings

March 16—Institute of Metal Finishing. London Branch. Northampton College of Advanced Technology, St. John Street, London, E.C.1. "Hydrogen Content of Electro-Deposits." E. Raub. 6.15 p.m.

March 16 — Institute of Production Engineers. Coventry Section. Craven Arms, High Street, Coventry. "The Mass Production of Forgings." R. E. Winch. 7.15 p.m.

March 17—Institute of Metals. South Wales Local Section. Department of Metallurgy, University College, Singleton Park, Swansea. Annual General Meeting, followed by "A General Review of Current Research Work in the Metallurgy Department, University College, Swansea." H. O'Neill. 6 p.m.

March 17—Institute of British Foundrymen. Slough Section. Lecture Theatre, High Duty Alloys Limited, Slough. "Mechanical Aids to Shell Moulding." D. H. Scott. 7.30 p.m.

March 18—Institute of British Foundrymen. Southampton Section. Technical College, St. Mary's Street, Southampton. "Cupola Experiments." K. G. Harris. 7.30 p.m.

March 18 — Manchester Metallurgical Society. Manchester Room, The Central Library, Manchester. "Metallurgical Background of Casting Production." A. Cibula. 6.30 p.m.

March 18—Institute of Metal Finishing. Organic Finishing Group. Exchange and Engineering Centre, Stephenson Place, Birmingham. "Paint Stripping Methods and Materials." J. R. Olivier. 6.30 p.m.

March 18 — Institute of Production Engineers. Swansea Section. Central Library, Swansea. "Properties of Pure Molybdenum Disulphide and Its Application to Production Engineering." H. Peter Jost. 7 p.m.

March 19—Institute of Metals. Birmingham Local Section. Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham. Annual General Meeting. 6.30 p.m.

March 20—Institute of Metal Finishing. Sheffield and North-East Branch. Grand Hotel, Cavendish Room, Sheffield. "Barrel Plating with Special Reference to Screw Threads." A. W. Wallbank. 7 p.m.

March 20 — Institution of Production Engineers. Cardiff Section. South Wales Institute of Engineers, Park Place, Cardiff. Annual General Meeting, followed by "Engineering Ceramics." C. G. Martin. 7 p.m.

Metal Market News

WITH the exception of tin, which fell away in a somewhat inexplicable manner on Friday last, all the metals registered gains, although copper closed substantially below the best. Trading was active all round and turnovers rather above the average. The trend on the Stock Exchange was steady, while Wall Street, although inclined to be erratic, was on the whole a bullish market. In spite of activity in Whittington Avenue, business with consumers was not brisk, although it may be presumed that those manufacturers having scale contracts with the facility of fixing back on the previous day's price made good use of the opportunities presented to them by the course of the market. The background of unrest in Nyasaland continued, and it must be admitted that the outlook in the Central African Federation is far from reassuring. In spite of this, and the obvious threat to production on the Copperbelt should racial strife spread to Northern Rhodesia, the standard market boiled over on the news that the shut-down at El Teniente had been called off and work resumed. Early in the week the report of a strike at the Arizona smelter and the trouble at the Braden property imparted a very firm tone to the copper ring, and eventually it began to look as though £250 would be reached. However, the advance stopped short of this, but on Thursday the quotation reached £248 for cash and £247 5s. 0d. three months. Early in the week it was known that the Cerro de Pasco strike was settled but that there was a go-slow movement at El Teniente. On Tuesday, the custom smelters' quotation went up by ½ cent to 31½ cents, and the following day one smelter was reported to be holding out for 32 cents.

Stocks of copper in official warehouses advanced by 247 tons to 7,217 tons, but in spite of this a backwardation ruled all though the week, and closing prices were £245 10s. 0d. cash and £245 three months. These figures showed a gain of £5 10s. 0d. in both positions, the turnover, apart from trading on the Kerb, being 12,200 tons. Business in the States is reported to be good, and the demand for copper on such a scale that dealers have been able to do better than 32 cents in making sales to users. Throughout the week trading on the Commodity Exchange was active, Thursday being a particularly brisk day with the volume of business well above the average. It had been stated that there was not a lot of demand from consumers, but a continuing shortage of scrap has compelled some users of this class of raw material to make purchases of refined copper. High-grade brass scrap of 70:30 quality is reported to be scarce, particularly Q.F. cases, of which not so many months ago there was an ample supply. Copper scrap, too, is understood to be far from plentiful and this would appear to add force to the users' plea that the ban on the export of secondary metal should not be lifted.

The turnover in lead was around 8,000 tons and the market firmed up on news of a half cent advance in the U.S. price to 11½ cents. On the Metal Exchange, March advanced by £1 10s. 0d. and June by £1 12s. 6d. to close at £71 5s. 0d. and £72 17s. 6d. for the respective positions. About 9,600 tons of zinc changed hands with an advance of 17s. 6d. in both positions, the close being £76 5s. 0d. and £74 5s. 0d. Stocks of tin in Metal Exchange warehouses declined by 636 tons to 12,849 tons, but after a turnover of 930 tons the market closed easy at £777 10s. 0d. for cash and £781 three months, while the afternoon Kerb market showed a further loss. On balance, cash was marked down by £4 and three months by an equal amount. A weakening of the Eastern price was probably responsible for the easier tone in London. Over the weekend it became known that the U.S. producers of copper had advanced their price to 31½ cents.

New York

Copper futures were very steady in active dealings. Physical copper continued firm and tight, with the railroad jurisdictional strike at Anaconda's Montana mines a possible firming factor. Shipments of ore from the mine to the smelter and refinery are down, although Anaconda said shipments from the refinery to customers are continuing. However, if the strike extends up to next Wednesday, shipments from the refinery will be affected, informed sources said. Meanwhile, the lone custom smelter who was still offering copper at 32 cents has now withdrawn from the market. Producers were selling copper at 30 cents to regular customers, with free copper very tight. Late in the afternoon, Anaconda raised the price of copper 1½ cents to 31½ cents, effective Monday. This move was followed by Phelps Dodge and Kennecott. Tin was weak, reflecting the lack of buyers. Lead recorded fair sales, but zinc was quiet. Lead sales for the week were placed at 20,919 tons.

United States imports of copper in 1958 were the lowest since 1940, according to figures released by the American Bureau of Metal Statistics on the basis of Bureau of Census records.

Total imports amounted to 448,410 short tons. Against this figure, the outflow of crude and refined copper in 1958 totalled 396,343 tons. So, on balance, the United States had net imports of 92,067 tons. In December, copper imports into the U.S. were down, while lead and zinc imports were up. The lead and zinc imports reflected catching up by some countries with their import quotas. December and November imports, in short tons respectively, were as follow:

Kaiser Aluminum and Chemical Corporation and Mexico Refractories Company of Missouri report that they have reached agreement on the terms of a proposed merger. Under the agreement, shareholders of Mexico Refractories will receive a total of 300,000 Kaiser shares and 150,000 shares of a new series of 100 dollars par 4¼ per cent convertible preference stock. Each of the two new shares will be convertible initially into two shares of Kaiser common stock. Subject to approval by shareholders of both companies in the near future, Mexico Refractories will merge into Kaiser Aluminum and will operate as a division in conjunction with Kaiser Chemicals Division in the production and sale of refractory products for high temperature industrial operations.

Aluminum Company of America has announced that one of two idle potlines at its Rockdale, Texas, smelter, will be restarted on March 16. It will be the second Alcoa facility of its kind to be put back into operation in a month.

Birmingham

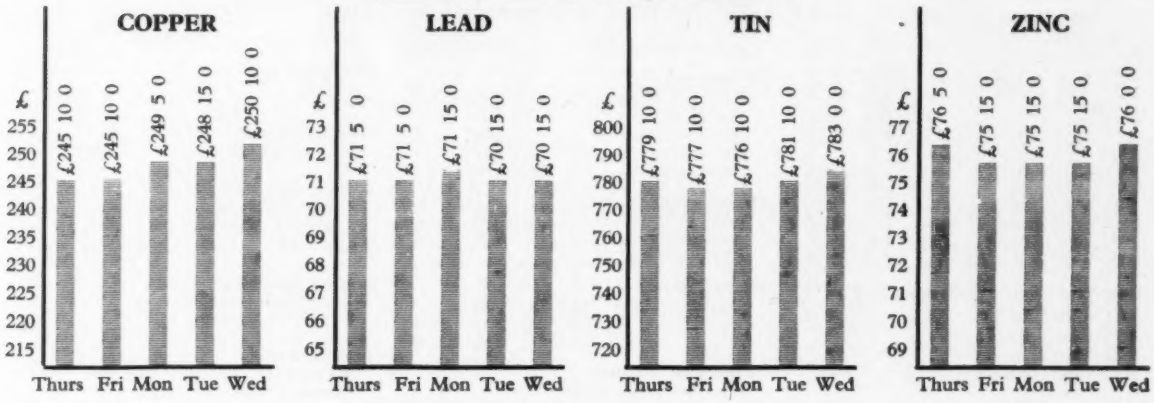
It would appear likely that unemployment in the Midland area has passed its peak. There was a slight improvement in the latest returns as compared with the position in January. Temporarily, the position is adversely affected by the strikes which are taking place in the motor trade. The building industry is gaining some momentum following a spell of easier weather, but as stocks of raw materials are heavy it may well be some time before metal manufacturers feel the effect. A machine tool firm in the Midlands will benefit from the large order recently placed by Russian interests. Domestic hardware sales show some expansion, and there are more orders for heating and cooking apparatus in which iron castings are used.

In the Midland iron and steel trade there are two notable exceptions in the general dullness which prevails, namely, a strong demand for heavy steel plates and also for sheets used in the motor trade. Re-rolling works are short of orders and stocks of semi-finished steel are being reduced only slowly. A lull is reported in the market for heavy structural steel, due to the falling off in placing of new building contracts on major works. On the other hand, steel bars used for reinforcing concrete are selling well. In the last quarter of 1958, production of iron castings in the East and West Midlands exceeded that of any other district.

Non-Ferrous Metal Prices

London Metal Exchange

Thursday 5 March to Wednesday 11 March 1959



Primary Metals

All prices quoted are those available at 2 p.m. 11/3/59

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		9	0
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		14	0
Columbite	per unit		—	
Copper H.C. Electro	ton	250	10	0
Fire Refined 99·70%	„	249	0	0
Fire Refined 99·50%	„	248	0	0

		£	s.	d.
Copper Sulphate	ton	78	0	0
Germanium	grm.		—	
Gold	oz.	12	9	4¾
Indium	„		10	0
Iridium	„	20	0	0
Lanthanum	grm.		15	0
Lead English	ton	70	15	0
Magnesium Ingots	lb.		2	3
Notched Bar	„		2	9½
Powder Grade 4	„		6	1
Alloy Ingot, A8 or AZ91	„		2	4
Manganese Metal	ton	247	0	0
Mercury	flask	74	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	

		£	s.	d.
Palladium	oz.	5	15	0
Platinum	„	28	10	0
Rhodium	„	40	0	0
Ruthenium	„	14	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	7⅜
Tellurium	lb.		15	0
Tin	ton	783	10	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	75	3	9
Dust 95/97%	„	109	0	0
Dust 98/99%	„	115	0	0
Granulated 99+%	„	100	3	9
Granulated 99·99+%	„	114	1	3

**Duty and Carriage to customers' works for buyers' account.*

Foreign Quotations

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton	**Canada** c/lb ≏ £/ton	**France** fr/kg ≏ £/ton	**Italy** lire/kg ≏ £/ton	**Switzerland** fr/kg ≏ £/ton	**United States** c/lb ≏ £/ton
Aluminium		22.50 185 17 6	210 157 10	375 221 5	2.50 212 10	26.80 214 10
Antimony 99.0			220 165 0	445 262 10		29.00 232 0
Cadmium			1,350 1,012 10			145.00 1,160 0
Copper						
Crude				475 280 5		
Wire bars 99.9 Electrolytic	34.50 252 0	29.00 239 10	329 246 15		2.95 250 15	31.50 252 0
Lead		10.50 86 15	104 88 0	167 98 10	.87 74 0	11.50 92 0
Magnesium						
Nickel		70.00 578 5	900 675 0	1,200 708 0	7.50 637 10	74.00 592 0
Tin	113.50 835 7 6		1,111 833 5	1,520 896 17 6	9.40 799 0	102.00 816 0
Zinc						
Prime western		11.25 93 0 0				11.00 88 0
High grade 99.95		11.85 97 17 6				
High grade 99.99		12.25 101 2 6				
Thermic			110.00 82 10			
Electrolytic			118.00 88 10	172 101 10	.93 79 0	12.25 98 0

D

Non-Ferrous Metal Prices (continued)

Ingot Metals

All prices quoted are those available at 2 p.m. 11/3/59

	£	s.	d.
Aluminium Alloy (Virgin)			
B.S. 1490 L.M.5 .... ton	210	0	0
B.S. 1490 L.M.6 .... „	202	0	0
B.S. 1490 L.M.7 .... „	216	0	0
B.S. 1490 L.M.8 .... „	203	0	0
B.S. 1490 L.M.9 .... „	203	0	0
B.S. 1490 L.M.10.... „	221	0	0
B.S. 1490 L.M.11.... „	215	0	0
B.S. 1490 L.M.12.... „	223	0	0
B.S. 1490 L.M.13.... „	216	0	0
B.S. 1490 L.M.14.... „	224	0	0
B.S. 1490 L.M.15.... „	210	0	0
B.S. 1490 L.M.16.... „	206	0	0
B.S. 1490 L.M.18.... „	203	0	0
B.S. 1490 L.M.22.... „	210	0	0
†Aluminium Alloys (Secondary)			
B.S. 1490 L.M.1 .... ton	—		
B.S. 1490 L.M.2 .... „	—		
B.S. 1490 L.M.4 .... „	—		
B.S. 1490 L.M.6 .... „	—		
***Aluminium Bronze**			
BSS 1400 AB.1..... ton	251	0	0
BSS 1400 AB.2..... „	—		

	£	s.	d.
***Brass**			
BSS 1400-B3 65/35 .. ton	•159	0	0
BSS 249..... „	—		
BSS 1400-B6 85/15 .. „	205	0	0
***Gunmetal**			
R.C.H. 3/4% ton .... „	—		
(85/5/5/5) ..... „	200	0	0
(86/7/5/2) ..... „	206	0	0
(88/10/2/1) ..... „	247	0	0
(88/10/2/½) ..... „	268	0	0
***Manganese Bronze**			
BSS 1400 HTB1.... „	196	0	0
BSS 1400 HTB2.... „	205	0	0
BSS 1400 HTB3.... „	—		
Nickel Silver			
Casting Quality 12% „	225	0	0
„ „ 16% „	235	0	0
„ „ 18% „	250	0	0
***Phosphor Bronze**			
B.S. 1400 P.B.1.(A.I.D. released) ..... „	295	0	0
B.S. 1400 L.P.B.1 .... „	217	0	0

**Average prices for the last week-end.*

	£	s.	d.
Phosphor Copper			
10% ..... ton	257	10	0
15% ..... „	260	0	0
Phosphor Tin			
5% ..... „	—		
Silicon Bronze			
BSS 1400-SB1 ..... „	260	0	0
Solder, soft, BSS 219			
Grade C Tinmans.... „	363	9	0
Grade D Plumbers.. „	293	0	0
Grade M ..... „	399	6	0
Solder, Brazing, BSS 1845			
Type 8 (Granulated) lb.	—		
Type 9 „ „	—		
Zinc Alloys			
Mazak III ..... ton	107	6	3
Mazak V ..... „	111	6	3
Kayem ..... „	117	6	3
Kayem II ..... „	123	6	3
Sodium-Zinc ..... lb.		2	6½

Semi-Fabricated Products

Prices vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium				
Sheet 10 S.W.G. lb.		2	8½	
Sheet 18 S.W.G. „		2	10½	
Sheet 24 S.W.G. „		3	1½	
Strip 10 S.W.G. „		2	8½	
Strip 18 S.W.G. „		2	9½	
Strip 24 S.W.G. „		2	11	
Circles 22 S.W.G. „		3	2½	
Circles 18 S.W.G. „		3	1½	
Circles 12 S.W.G. „		3	0½	
Plate as rolled ..... „		2	8	
Sections ..... „		3	2	
Wire 10 S.W.G. .... „		2	11½	
Tubes 1 in. o.d. 16 S.W.G. ..... „		4	1	
Aluminium Alloys				
BS1470. HS10W.				
Sheet 10 S.W.G. „		3	1	
Sheet 18 S.W.G. „		3	3½	
Sheet 24 S.W.G. „		3	11	
Strip 10 S.W.G. „		3	1	
Strip 18 S.W.G. „		3	2½	
Strip 24 S.W.G. „		3	10½	
BS1477. HP30M.				
Plate as rolled..... „		2	11	
BS1470. HC15WP.				
Sheet 10 S.W.G. „		3	9½	
Sheet 18 S.W.G. „		4	2	
Sheet 24 S.W.G. „		5	0½	
Strip 10 S.W.G. „		3	10½	
Strip 18 S.W.G. „		4	2	
Strip 24 S.W.G. „		4	9½	
BS1477. HPC15WP.				
Plate heat treated.. „		3	6½	
BS1475. HG10W.				
Wire 10 S.W.G. „		3	10½	
BS1471. HT10WP.				
Tubes 1 in. o.d. 16 S.W.G. ..... „		5	0½	
BS1476. HE10WP.				
Sections ..... „		3	1½	
Brass				
Tubes..... „		1	11	
Brazed Tubes..... „	—			
Drawn Strip Sections „	—			
Sheet ..... ton	—			
Strip ..... „	260	0	0	
Extruded Bar..... lb.		2	0½	
Extruded Bar (Pure Metal Basis) ..... „	—			

Brass				
Condenser Plate (Yellow Metal) ..... ton	195	0	0	
Condenser Plate (Naval Brass) ..... „	207	0	0	
Wire ..... lb.		2	8½	
Beryllium Copper				
Strip ..... „	1	4	11	
Rod..... „	1	1	6	
Wire ..... „	1	4	9	
Copper				
Tubes ..... lb.		2	4½	
Sheet ..... ton	278	15	0	
Strip ..... „	278	15	0	
Plain Plates ..... „	—			
Locomotive Rods .... „	—			
H.C. Wire ..... „	296	5	0	
Cupro Nickel				
Tubes 70/30 ..... lb.		3	7½	

Lead				
Pipes (London) .... ton	112	5	0	
Sheet (London) .... „	110	0	0	
Tellurium Lead .... „	£6 extra			
Nickel Silver				
Sheet and Strip 7% .. lb.		3	8	
Wire 10% ..... „		4	2½	
Phosphor Bronze				
Wire ..... „		4	2½	
Titanium (1,000 lb. lots)				
Billet over 4″ dia.-18″ dia. lb.	63/-		64/-	
Rod 4″ dia.-·250″ dia. „	75/-		112/-	
Wire under ·250″ dia.-·036″ dia. ..... „	146/-		222/-	
Sheet 8′ × 2′ × ·250″-·010″	88/-		157/-	
Strip ·048″-·003″..... „	100/-		350/-	
Tube..... „			300/-	
Extrusions ..... „			120/-	
Zinc				
Sheet ..... ton	110	10	0	
Strip ..... „		nom.		

Domestic and Foreign

Merchants' average buying prices delivered, per ton, 10/3/59.

	£
Aluminium	
New Cuttings	145
Old Rolled	125
Segregated Turnings	96
Brass	
Cuttings	168
Rod Ends	151
Heavy Yellow	128
Light	123
Rolled	158
Collected Scrap	126
Turnings	145
Copper	
Wire	223
Firebox, cut up	217
Heavy	213
Light	208
Cuttings	223
Turnings	203
Braziery	173

	£
Gunmetal	
Gear Wheels	195
Admiralty.....	195
Commercial	170
Turnings	165
Lead	
Scrap	61
Nickel	
Cuttings	—
Anodes	548
Phosphor Bronze	
Scrap	170
Turnings	165
Zinc	
Remelted	57
Cuttings	53
Old Zinc	37

Financial News

LIGHT METALS STATISTICS IN JAPAN
(November, 1958)

Classification	Production	Shipment	Stock	Export
Alumina	23,936	25,693	11,788	9,201
Aluminium				
Primary	7,812	7,513	3,771	0
Secondary	2,141	2,096	338	0
Rolled Products	6,457	6,398	1,971	536
Electric Wire	465	373	1,037	66
Sheet Products	1,548	1,533	1,156	69
Castings	1,665	—	—	—
Die-Castings	1,089	—	—	—
Forgings	58	—	—	—
Powder	—	—	—	—
Primary Aluminium (December)	7,661	7,822	3,610	0
Sponge Titanium	145	—	—	170
Magnesium	96	86	13	0
Secondary	172	181	271	0

Norton Industries

Group net profit year ended October 31, 1958, £52,601 (£59,202), and dividend 20 per cent (same). Fixed assets £316,149 (£290,374), current assets £539,247 (£578,049), and liabilities £432,566 (£473,490). Commitments £15,000 (£33,200).

London Electric Wire

It has been announced by Associated Electrical Industries that its offer for the capital of the London Electric Wire Company and Smiths has been accepted in respect of more than 90 per cent in value of both the Preference and Ordinary stocks and that, subject only to permission being granted to deal in the new shares, the offer is unconditional.

International Tin Agreement

Speaking at the annual meeting of the Petaling Tin Company in Ipoh last week, Mr. J. T. Chappel said that events of the past year had shown a serious weakness in the operation of the International Tin Agreement. This weakness, he said, lay in the fact that non-participating countries such as China and Russia had been in a position to sell unlimited quantities of tin at prices only maintained by drastic curtailment of exports by the signatory producing countries.

Continuing, Mr. Chappel said that in his view it was essential that this position should be rectified, as Malayan producers could not be expected to continue indefinitely the current heavy restriction on their sales in order to maintain a tin price at which non-participating countries could sell any quantities available in excess of their own requirements of the metal.

Hilger and Watts Ltd.

Group net profit, year to September 30, 1958, £112,754 (£87,690), dividend 13 per cent (same), plus 2 per cent special interim. Fixed assets £659,752 (£618,872). Current assets £1,107,047 (£1,083,153), liabilities £428,914 (£481,684), including overdraft £67,985 (£143,094). Reserves £459,171 (£361,162). Future tax £94,515 (£81,480). Commitments £75,337.

An Integration

Owing to the increased demand for their floor warming systems and heating equipment, it has been announced by **Panelec (Great Britain) Ltd.** that their activities will be integrated with those of the parent company, British Insulated Callender's Cables Ltd., at the end of this present month.

This change of organization is being carried out to enable full advantage to be taken of the greater production and commercial resources now available to assist expansion in the rapidly developing field of floor warming. "Panelec" will be retained as the trade name for the new Heating Division of B.I.C.C.

New Copper Plant

Recent news from Cape Town is that the Messina Transvaal Development Company is to proceed immediately with the building of a smelting and refining plant in Southern Rhodesia for the production of fire-refined copper.

A new company, the Messina Rhodesia Smelting and Refining Company, will be formed with an initial capital of £750,000, of which £600,000 will be subscribed by Messina Transvaal Development Company and £150,000 by MTD Mangula Limited. The primary purpose of the plant will be to treat the output of MTD Mangula and other copper properties in Southern Rhodesia. It is also intended to operate as a custom smelter. The plant is estimated to be in operation within 18 months.

Scrap Metal Prices

The figures in brackets give the English equivalents in £1 per ton:—

West Germany (D-marks per 100 kilos):

Used copper wire ..	(£201.10.0)	230
Heavy copper	(£201.10.0)	230
Light copper	(£166.10.0)	190
Heavy brass	(£113.17.6)	130
Light brass	(£87.12.6)	100
Soft lead scrap	(£56.0.0)	64
Zinc scrap	(£39.10.0)	45
Used aluminium unsorted	(£78.16.0)	90

France (francs per kilo):

Electrolytic copper scrap	(£195.0.0)	260
Heavy copper	(£195.0.0)	260
No. 1 copper wire ..	(£183.15.0)	245
Light brass	(£116.5.0)	155
Zinc castings	(£48.15.0)	65
Lead	(£67.10.0)	90
Aluminium	(£112.10.0)	150

Italy (lire per kilo):

Aluminium soft sheet clippings (new) ..	(£197.12.6)	335
Aluminium copper alloy	(£126.17.6)	215
Lead, soft, first quality	(£79.0.0)	134
Lead, battery plates	(£43.12.6)	74
Copper, first grade	(£221.5.0)	375
Copper, second grade	(£207.0.0)	350
Bronze, first quality machinery	(£209.10.0)	355
Bronze, commercial gunmetal	(£180.0.0)	305
Brass, heavy.....	(£144.10.0)	245
Brass, light	(£129.17.6)	220
Brass, bar turnings ..	(£132.15.0)	225
New zinc sheet clippings	(£57.5.0)	97
Old zinc	(£42.10.0)	72

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

Midland Metal Recovery Company Limited (620473), Paramount House, Market Square, Stafford. Registered February 6, 1959. Nominal capital, £1,000 in £1 shares. Directors: George Perkins, Anthony G. Y. Perkins and Trevor L. Y. Perkins.

Reginald Lloyd Limited (620548), 2 Church Road, Stanmore, Middx. Registered February 6, 1959. To carry on business of manufacturers of and dealers in tinning and soldering compounds and all articles and accessories used in connection therewith and in the engineering industry generally, etc. Nominal capital, £100 in £1 shares. Directors: Leonard J. Bennett and Maurice G. Hardy.

Rodway and Taylor (B'ham) Limited (620620), 85-90 Buckingham Street, Birmingham, 9. Registered February 9, 1959. To carry on business of manufacturers of and dealers in dust and fume extraction and conveying plant, etc. Nominal capital, £12,500 in £1 shares. Directors Rowland Rodway and Mrs. Edna B. M. Rodway.

G. Smith Enamelling and Plating Co. Limited (620636), 382 St. John Street, London, E.C.1. Registered February 9, 1959. Nominal capital £1,000 in £1 shares. Directors: George E. Smith, Lionel Smith and Mrs. Ivy V. Sealey.

Devonarc Welding Company Limited (621367), Marsh Barton Road, Marsh Barton Trading Estate, Exeter. Registered February 19, 1959. Nominal capital, £500 in £1 shares. Directors: John K. Gibbon, Mrs. Lily Gibbon and John Gibbon.

Linton and Co. (Consultants) Limited (621469), 21a High Street, Teddington, Middx. Registered February 20, 1959. To carry on business of consulting engineers, metallurgists, etc. Nominal capital, £500 in £1 shares. Directors: Fredk. W. Burnet-Craigie and Roy J. Climpson.

Parliamentary News

By Our Lobby Correspondent

Non-Ferrous Mining. — At Question Time in the Commons, Mr. J. W. Ainsley (Lab., Durham, N.W.) asked the President of the Board of Trade whether, in order to encourage the full exploitation of the non-ferrous mining potentialities in Weardale, County Durham, such as were listed in Paper No. 7, delivered in September, 1958, by Professor K. C. Dunham to the Institute of Mining and Metallurgy, a copy of which had been sent to him, he would consider giving financial aid to the industries concerned.

The President of the Board of Trade, Sir David Eccles, replied that Weardale was not a D.A.T.A.C. area. The exploitation of those non-ferrous minerals was a matter for private enterprise.

THE STOCK EXCHANGE

Markets Moderately Busy But Generally Featureless

ISSUED CAPITAL •	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 10 MARCH	+RISE—FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1959 HIGH	1959 LOW	1958 HIGH	1958 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	24/–	+6d.	9	10	7 10 0	24/10½	23/3	24/9	17/6
400,000	2/–	Anti-Attrition Metal	1/6		4	8½	5 6 9	—	—	1/9	1/3
41,305,038	Stk. (£1)	Associated Electrical Industries ...	55/9	+1/–	15	15	5 7 0	59/–	54/–	58/9	46/6
1,609,032	1	Birfield	51/6	—4/6	15	15	5 16 6	59/–	51/6	62/4½	46/3
3,196,667	1	Birmid Industries	73/9	—6d.	17½	17½	4 15 0	76/10½	72/–	77/6	55/3
5,630,344	Stk. (£1)	Birmingham Small Arms	36/9		11	10	5 19 9	40/4½	36/1½	39/–	23/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	16/3		5	5	6 3 0	16/3	15/–	16/1½	14/7½
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	17/9		6	6	6 15 3	18/1½	17/9	17/4½	16/6
500,000	1	Bolton (Thos.) & Sons	27/6		10	12½	7 5 6	28/3	27/6	28/9	24/–
300,000	1	Ditto Pref. 5%	15/–		5	5	6 13 3	15/3	15/–	16/–	15/–
160,000	1	Booth (James) & Co. Cum. Pref. 7%	20/6		7	7	6 16 6	—	—	20/4½	19/–
1,500,000	Stk. (£1)	British Aluminium Co. Pref. 6% ...	19/6	+9d.	6	6	6 3 0	19/7½	18/9	20/–	18/4½
15,000,000	Stk. (£1)	British Insulated Callender's Cables	47/6	—3d.	12½	12½	5 5 3	52/–	47/6	52/6	38/9
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord. ...	53/6	+1/3	10	10	3 14 9	55/1½	49/3	52/–	28/3
600,000	Stk. (5/–)	Canning (W.) & Co.	25/1½	—1½d.	25+	*2½C	25 4 19 6	25/6	24/9	25/3	19/3
60,484	1/–	Carr (Chas.)	1/4½		12½	25	9 1 9	—	—	2/3	1/4½
150,000	2/–	Case (Alfred) & Co. Ltd.	5/1½		25	25	9 15 0	5/2½	4/7½	5/3	4/–
555,000	1	Clifford (Chas.) Ltd.	22/9		10	10	8 15 9	22/6	22/6	22/–	16/–
45,000	1	Ditto Cum. Pref. 6%	15/3		6	6	7 17 6	—	—	16/–	15/–
250,000	2/–	Coley Metals	3/–		20	25	13 6 9	3/3	2/10½	4/6	2/6
8,730,596	1	Cons. Zinc Corp.†	64/–	+2/–	18¾	22½	5 16 0	67/6	60/6	65/3	41/–
1,509,528	1	Davy & United	96/–		20	15	4 3 3	96/–	86/–	87/–	45/9
2,915,000	5/–	Delta Metal	25/3	—6d.	30	*17½	5 18 9	27/–	24/1½	25/–	17/7½
4,600,000	Stk. (£1)	Enfield Rolling Mills Ltd.	44/3	—9d.	12½	15B	5 13 0	46/6	36/7½	38/–	22/9
750,000	1	Evered & Co.	31/–		10§	15 Z	6 9 0	31/3	30/–	30/–	26/–
18,000,000	Stk. (£1)	General Electric Co.	31/3	—9d.	10P	12½		40/3	31/10½	40/6	29/6
1,500,000	Stk. (10/–)	General Refractories Ltd.	36/6	—2/3	20	20	5 9 6	40/–	36/6	39/3	27/3
401,240	1	Gibbons (Dudley) Ltd.	64/–		15	15	4 13 6	66/6	65/–	67/6	61/–
750,000	5/–	Glacier Metal Co. Ltd.	6/9		11½	11½	8 10 3	7/1½	6/7½	8/3	5/–
1,750,000	5/–	Glynwed Tubes	17/6	—1/–	20	20	5 14 3	19/3	16/4½	18/1½	12/10½
5,421,049	10/–	Goodlass Wall & Lead Industries ...	30/6	—9d.	13‖	18Z	4 5 3	31/6	28/7½	30/9	17/3
342,195	1	Greenwood & Batley	79/6		20	17½	5 0 6	83/9	75/–	57/9	45/–
396,000	5/–	Harrison (B'ham) Ord.	15/–		*15	*15	5 0 0	15/3	15/–	15/9	11/6
150,000	1	Ditto Cum. Pref. 7%	19/6		7	7	7 3 6	—	—	19/9	18/4½
1,075,167	5/–	Heenan Group	7/9		10	10‡	6 9 0	8/3	7/6	9/7½	6/9
236,958,260	Stk. (£1)	Imperial Chemical Industries ...	34/10½	—1/3	12Z	10	4 11 9	38/3	33/9	38/–	24/3
34,736,773	Stk. (£1)	Ditto Cum. Pref. 5%	16/9		5	5	5 19 6	16/10½	16/–	17/1½	16/–
14,584,025	**	International Nickel	170½	+6	$2.60	$3.75	2 14 6	170½	153	169	132¾
860,000	5/–	Jenks (E. P.), Ltd.	9/3		14	27½φ	7 11 3	10/–	8/9	10/–	6/7½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	16/3		5	5	6 3 0	16/3	15/4½	16/9	15/–
3,987,435	1	Ditto Ord.	51/3	—1/3	10	10	3 18 0	52/6	44/3	47/–	36/6
600,000	10/–	Keith, Blackman	27/6		17½E	15	6 7 3	27/6	25/–	28/9	15/–
320,000	4/–	London Aluminium	5/3	—1½d.	10	10	7 12 6	6/–	5/3	6/–	3/–
2,400,000	1	London Elec. Wire & Smith's Ord. ...	71/3	+1/9	15	12½	4 4 3	74/6	69/6	74/–	39/9
400,000	1	Ditto Pref.	24/9		7½	7½	6 1 3	25/3	24/3	24/3	22/–
765,012	1	McKechnie Brothers Ord.	43/3		15	15	6 18 6	45/–	43/3	45/–	32/–
1,530,024	1	Ditto A Ord.	41/3		15	15	7 5 6	43/6	41/3	45/–	30/–
1,108,268	5/–	Manganese Bronze & Brass	14/3		20	27½‡	7 0 3	14/3	13/9	14/1½	8/9
50,628	6/–	Ditto (7½% N.C. Pref.)	6/–		7½	7½	7 10 0	—	—	6/3	5/6
13,098,855	Stk. (£1)	Metal Box	75/–	+9d.	11	11	2 13 3	75/–	66/6	73/3	40/6
415,760	Stk. (2/–)	Metal Traders	9/–		50	50	11 2 3	9/1½	1/6	9/–	6/3
160,000	1	Mint (The) Birmingham	22/6		10	10	8 17 9	22/6	22/–	22/9	19/–
80,000	5	Ditto Pref. 6%	70/6		6	6	8 10 3	75/6	69/–	83/6	69/–
3,705,670	Stk. (£1)	Morgan Crucible A	44/–	+6d.	10	10	4 11 0	45/9	43/6	45/–	34/–
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/9xd		5½	5½	6 4 0	18/6	18/–	18/–	17/–
2,200,000	Stk. (£1)	Murex	49/6	+4/6	17½	20	7 1 3	49/6	42/–	58/9	46/–
468,000	5/–	Ratcliffs (Great Bridge)	10/4½		10	10	4 16 6	11/3	10/4½	11/1½	6/10½
234,960	10/–	Sanderson Bros. & Newbould ...	28/3		20	27½D	7 1 6	28/3	27/9	27/3	24/6
1,365,000	Stk. (5/–)	Serck	18/1½	+1½d.	15	17½	4 3 0	19/–	18/–	18/7½	11/–
6,698,586	Stk. (£1)	Stone-Platt Industries	44/6		15	12½	6 14 9	46/9	43/3	45/6	22/6
2,928,963	Stk. (£1)	Ditto 5½% Cum. Pref.	16/1½		5½	5½	6 16 6	16/7½	15/10½	16/3	12/7½
18,255,218	Stk. (£1)	Tube Investments Ord.	80/1½	—1/10½	17½	15	4 7 6	83/3	72/–	86/–	48/4½
41,000,000	Stk. (£1)	Vickers	31/3	—2/–	10	10	6 8 0	37/–	31/3	36/3	28/9
750,000	Stk. (£1)	Ditto Pref. 5%	14/9		5	5	6 15 6	15/0¾	14/7½	15/9	14/3
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	21/6		*5	*5	7 3 6A	22/7½	21/7½	23/–	21/3
2,200,000	1	Ward (Thos. W.), Ord.	83/6	—3d.	20	15	4 15 9	87/6	83/6	87/3	70/9
2,666,034	Stk. (£1)	Westinghouse Brake	43/6	—3d.	10	10	4 12 0	47/–	39/9	46/6	32/6
225,000	2/–	Wolverhampton Die-Casting ...	9/–		30	25	6 13 3	9/–	8/8½	10/1½	7/–
591,000	5/–	Wolverhampton Metal	23/–	+6d.	27½	27½	5 19 6	23/–	21/6	22/9	14/9
78,465	2/6	Wright, Bindley & Gell	6/3	+3d.	20	20	8 0 0	6/4½	4/11½	5/4½	2/9
124,140	1	Ditto Cum. Pref. 6%	13/6		6	6	8 17 9	—	—	13/–	11/3
150,000	1/–	Zinc Alloy Rust Proof	3/–	+3d.	27	40D	9 0 0	3/–	2/9	3/1½	2/7½

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting **Shares of no Par Value. ‡ and 100% Capitalized Issue. •The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. Y Calculated on 11½% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. φ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits. E and 50% Capitalized issue in 7% 2nd Pref. Shares. P Interim dividend since reduced. § And Special distribution of 2½% free of tax.

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Chianti or copper, Italians know 'a drop of good stuff' when they see it! When it comes to melting, they and foundrymen the world over, rely on SKLENAR furnaces, recognised as the best by far wherever metal is processed.

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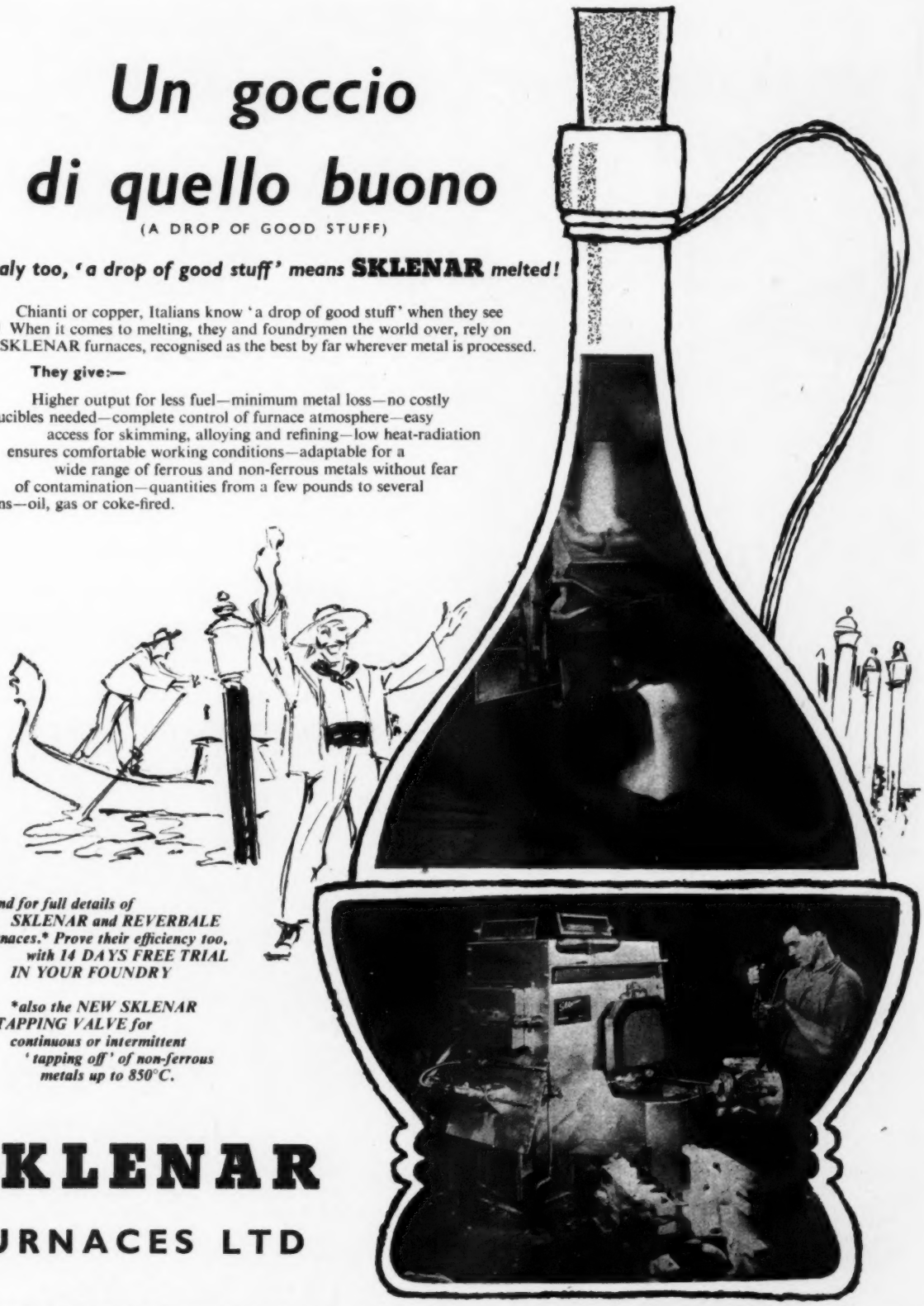

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E

Brass and Copper PLATES... SHEET... STRIP...

Manufacturing Range

PLATES	Maximum Length	16 ft.
	Maximum Width	4 ft. 6 ins.
	Maximum Weight	12 cwts.
SHEETS	***Cold Rolled***	
	Maximum Width ...	3 ft. 4 ins.
	Minimum Thickness ...	28 S.W.G.
	Hot Rolled	
	Maximum Width ...	4 ft. 6 ins.
	Minimum Thickness ...	26 S.W.G.
STRIP	Maximum Width ...	1 ft. 2 ins.
	Minimum Thickness ...	30 S.W.G.

For full particulars of the above and other products consult our reference book "Non-Ferrous Products." A copy will be sent on request.

VICKERS

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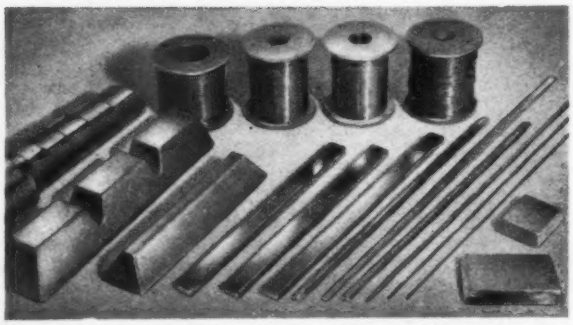

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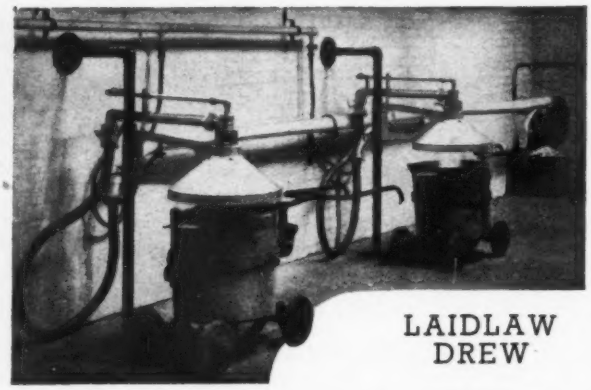

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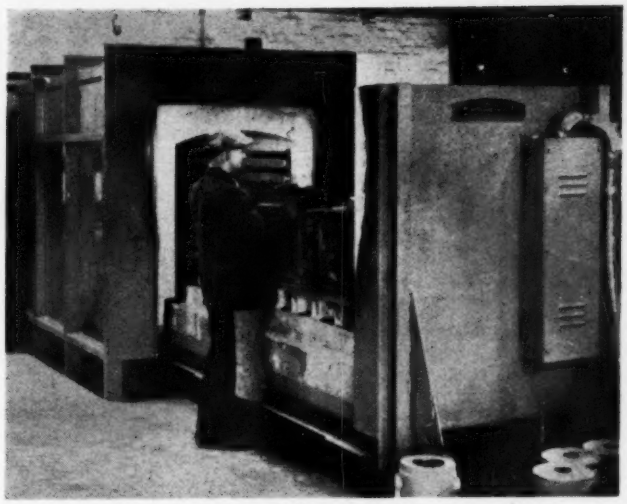

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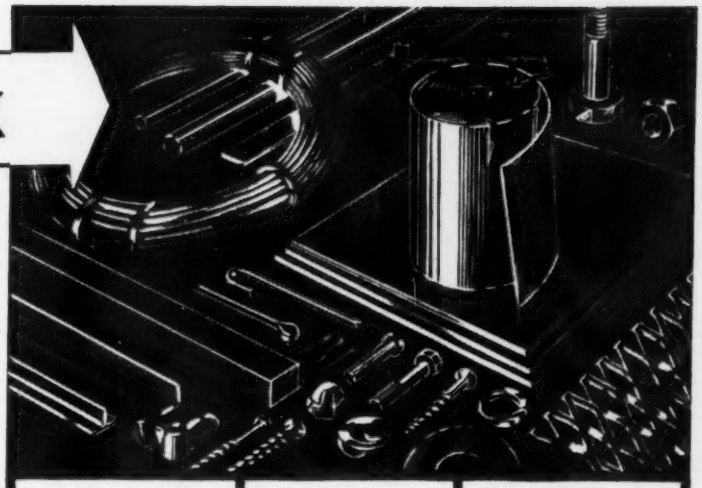

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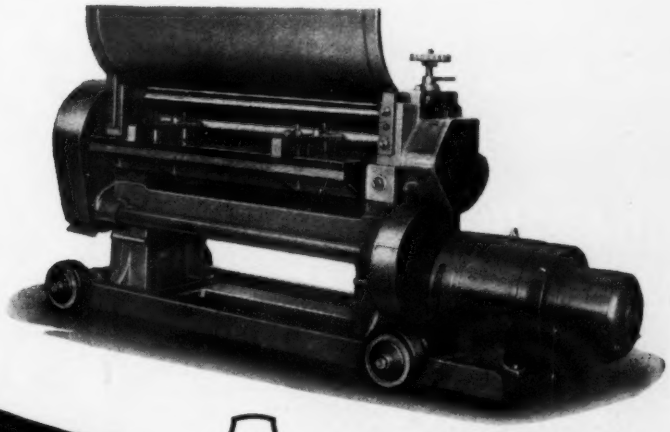

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